# CRETACEOUS FAUNAS FROM ZULULAND AND NATAL, SOUTH AFRICA

## INTRODUCTION, STRATIGRAPHY

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# CRETACEOUS FAUNAS FROM ZULULAND AND NATAL, SOUTH AFRICA

# INTRODUCTION, STRATIGRAPHY

*By* WILLIAM J. KENNEDY AND HERBERT C. KLINGER

CONTENTS

## SYNOPSIS

Cretaceous sediments outcrop in two main areas in eastern South Africa, north of Durban, from the Mfolozi River to the Mozambique border, and to the south, between the Itongazi and Mpenjati Rivers.

The term *Zululand Group* is proposed for the succession in the northern area, subdivided into : (1) The Makatini Formation (Upper Barremian to Aptian) ; (2) The Mzinene Formation (Albian to Cenomanian) ; (3) The St Lucia Formation (Coniacian to Maastrichtian). The term 'Umzamba Formation' is retained for the Coniacian to Campanian sequences south of Durban.

Sedimentation began in Lower Cretaceous (pre-Upper Barremian) times, with deposition of piedmont fan and fluviatile sands and conglomerates in northern Zululand. Transgression, beginning during the Upper Barremian, extended through at least into Albian, and probably Cenomanian, times, depositing first sands and conglomerates, followed by glauconitic silts. During late Cenomanian or early Turonian times, regression was under way, accompanied by widespread penecontemporaneous erosion. The highest Cenomanian and all the Turonian are thus absent on land. Renewed transgression during the early Coniacian extended through into at least the Campanian, and the base of the Senonian is diachronous. In northern Zululand, Coniacian silts rest on lithologically similar Upper Cenomanian deposits. Along the Mfolozi River, slightly higher horizons in the Coniacian rest first on Lower Cretaceous conglomerates and, to the south, overstep onto Stormberg Basalts and Basement rocks. South of Durban, yet higher horizons in the Coniacian rest on formations down to the Table Mountain Sandstone.

Preliminary work on the ammonite faunas allows subdivision of the Barremian to Lower Maastrichtian stages into 31 widely recognizable units and points to the development of a refined biostratigraphy when systematic work is complete. Apart from ammonites, the Cretaceous sequences described yield a rich fauna. Bivalves, gastropods and nautiloids are abundant, with scarcer echinoids, brachiopods, bryozoans and corals. Locality details of 185 sections in the area are given as a basis for subsequent taxonomic work.

## I. INTRODUCTION

During the summers of 1970–71 we collected from and measured the sections at over 150 localities in the Cretaceous successions of Zululand, Natal, and the Northern Transkei. Many of the fossils collected have been added to the collections of the British Museum (Natural History), which already contain classic South African material described by Daniel Sharpe, G. C. Crick, R. B. Newton, R. Etheridge, L. F. Spath and others, examined by us.

In addition, we have studied important collections in the Geological Survey of South Africa at Pretoria, including material collected by one of us (H. C. K.), by E. C. N. van Hoepen, S. H. Haughton and others. We have also been able to study the collections of the Transvaal Museum, the National Museum Bloemfontein, the South African Museum, Cape Town, the Durban Museum, and the University Collections at Durban and Pretoria.

The present publication is the first of a series in which we intend to describe the invertebrate faunas collected in this region. This work will need many years of study, for the South African Cretaceous yields diverse faunas which, in spite of an extensive literature (Haughton, 1959, provides the most complete bibliography), remain largely unknown in contemporary terms, whilst an acceptable stratigraphic framework is still lacking. Detailed biostratigraphy must await the results of further research, as must palaeoecological and palaeoenvironmental syntheses ; we present here an outline of the geological history of the area, a provisional biostratigraphy upon which to base our systematic work, and locality information of relevant sections.

## II. PLACE NAMES

Over most of the area described in this paper, place names are taken from the Second Edition of the 1 : 50 000 and the 1 : 250 000 topographic maps of South Africa. Standardization of spelling of Zulu names leads to the alteration of the names of many classic localities. Thus the Umsinene becomes the Mzinene, Manuan becomes Munywana, and so on.

## III. STRATIGRAPHIC SYNTHESIS

Cretaceous sediments outcrop in two main areas in eastern South Africa (Fig. 1) ; in Zululand, from the Mozambique border south to Umkwelane Hill on the Mfolozi River, and south of Durban, as reefs exposed only at low tide as between the Itongazi and Mpenjati Rivers, or in low cliffs, as at the mouth of the Umzamba River. There are small but important outcrops at Enseleni Reserve, and subsurface Cretaceous is recorded at Durban and Richards Bay.

Exposures are poor in the region studied, whilst dips are low and difficult to measure. The probable thickness of the Cretaceous in the St Lucia area is of the order of 1000 m, but the sequence quite clearly thickens northwards and eastwards, suggesting the presence of a substantial wedge of sediment out to sea.

In northern Zululand, coarse clastic pre-Upper Barremian fluviatile Cretaceous sediments rest on Jurassic Lebombo Volcanics. The lowest marine horizons known consist of Upper Barremian silts, sandstones and conglomerates. The succeeding Aptian has a similar facies, and in the area around Hluhluwe, this too rests on the Lebombos. The Albian/Aptian boundary is an important non-sequence marked by a horizon of hiatus concretions (Kennedy & Klinger 1972) which can be traced for 175 km, from Ndumu to 12 km north of Mtubatuba. Lowermost Albian sediments seem to be wholly absent in Zululand. Locally, the Albian may overlap onto Lebombo Volcanics. In general, however, the Albian forms an expanded sequence of shallow marine silts and sands, sometimes glauconitic, with shelly concretionary

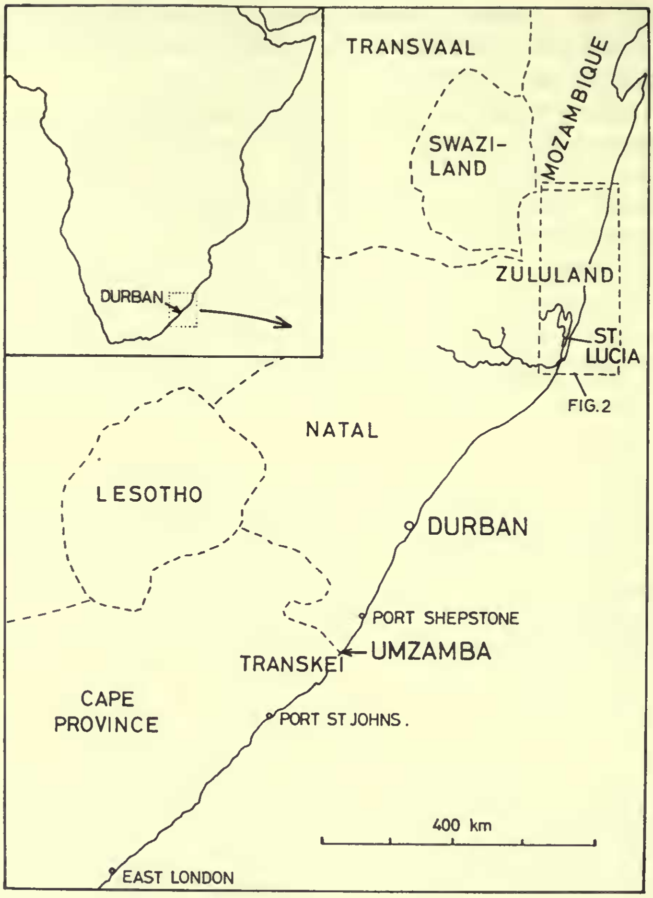


FIG. 1. Locations of the areas studied.

horizons and small-scale sedimentary cycles. Locally a more marginal basal conglomeratic facies may be developed. Horizons up to and including the *Stoliczkaia dispar* Zone have been recognized, followed by a conformable Lower, Middle and Upper Cenomanian sequence, again in a silty glauconitic facies, and with a rich marine fauna.

Turonian rocks are absent on land in Zululand, and along the Mzinene River a Coniacian basal conglomerate rests on Cenomanian silts, with a horizon of hiatus concretions at the contact (Kennedy & Klinger 1972). Along the Mzinene, Hluhluwe and Nyalazi Rivers, around False Bay and Lake St Lucia, a succession from Coniacian through to Lower Maastrichtian can be traced; the sequence is, throughout, one of shelly, sometimes glauconitic, silts, with concretionary horizons.

The next extensive outcrops of Cretaceous sediments appear along the Mfolozi River and at Umkwelane Hill (Fig. 1). At Riverview, Lower Coniacian sediments rest on Lower Cretaceous non-marine fluviatile conglomerates, and to the south, at

Umkwelane Hill, overstep onto Stormberg Basalts and granitic basement rocks within a distance of only a few kilometres. The basal Coniacian is a thin conglomerate; fossils from just above the base of the sequence at Umkwelane Hill suggest a horizon higher than that seen in the basal Coniacian along the Mzinene. Above, there is a succession of silts and shelly limestones extending up to the Lower Campanian. Probable Upper Campanian silts occur to the east, and around Monzi horizons up to the Lower Maastrichtian are present.

Cretaceous silts and shell beds are known beneath Durban, and sparse faunas indicate the presence of horizons in the Campanian and high in the Santonian. South of Durban, the deposits of the Upper Cretaceous transgression rest on horizons down to the Table Mountain Sandstone. The age of these, the Umzamba Beds, has long been disputed (p. 270), but a high Coniacian (?) to Campanian age seems most likely.

Available evidence thus indicates that sedimentation began in Lower Cretaceous (pre-Upper Barremian) times, with deposition of piedmont fan and fluviatile sands and conglomerates. Transgression, beginning during the Upper Barremian, extended through at least into Albian, and probably Cenomanian, times, but during late Cenomanian or early Turonian times regression was under way, accompanied by widespread penecontemporaneous erosion. Renewed transgression during the early Coniacian extended through into the Campanian at least, and the base of the Senonian is diachronous from Zululand, 600 km to the south, into the Northern Transkei.

## IV. HISTORY OF RESEARCH

The Cretaceous rocks of eastern South Africa were first discovered by H. F. Fynn in 1824, although they were not described until three decades later. Thus Captain R. J. Garden (1855 : 453–454) gave as graphic and accurate a picture of the Umzamba Beds as any during the following century:

> '... the lowest rock visible is a hard shelly rock with pebbles; above it is a brownish-red sandstone, traversed in every direction by white veins, which are the broken edges of colossal bivalve shells (*Inoceramus*). The shells are thin, and too easily broken to be extracted from the rock ... alternate layers of the above mentioned two rocks occur to the height of about eighteen feet, above which are hard bluish-black, brown and greenish argillaceous and sandy beds. Shells were found in all these clay beds, and Ammonites at different heights, and in certain of the strata ... Fossil trees are seen at low water on a reef of flat rocks (nearby).'

The fossils collected by Garden were described by W. H. Bailey in the succeeding pages of the *Quarterly Journal of the Geological Society of London*.

This section passed into the literature as the Umtamvuna or Umtamfuna Cretaceous (Tate 1867, Griesbach 1871, Gottsche 1887, Etheridge 1904, Crick 1907b, 1907d, and others), on the basis of the misconception that they outcrop at the mouth of the Umtamvuna River, although Griesbach (1871) refers to them as the Izindhluzabalungu Deposits. Latterly, they have become known as the Umzamba Beds, and in addition to the type section, outcrops have been described at several localities along the coast of southern Natal (Pondoland), in particular between the Itongazi and Umkandandhlouvu Rivers (Griesbach 1871, Rogers & Schwartz 1901, 1902, Crick 1907b, Plows 1921, Gevers & Little 1956, du Toit 1920, 1954, Haughton 1969). The most satisfactory description of the type section is that of Plows (1921). Faunas and floras have been described by Griesbach (1871), Chapman (1904, 1923), Lang (1906), Woods (1906), Rennie (1930, 1935), Spath (1921b, 1922a), van Hoepen (1920, 1921, 1966a), Broom (1907), Crick (1907b), Little (1957), Smitter (1956), Mandel (1960), Muller-Stoll & Mandel (1962), and Dingle (1969).

The age suggested for the Umzamba Beds has varied from Albian or Cenomanian to Maastrichtian, and the view long accepted that but a single faunal horizon is represented (Woods 1906, Rennie 1930, du Toit 1954). The most recent appraisal of the ammonites by Spath (1953) led him to suggest a Campanian to Lower Maastrichtian age for the fauna, and the latest microfaunal study led Dingle (1969) to a similar conclusion.

In fact, the base of the Umzamba Beds in the type section has yielded a Coniacian collignoniceratid : *Subprionotropis cricki* (Spath) (= *Barroisiceras umzambiensis* van Hoepen), whilst inoceramids and ammonites from higher in the section are of Santonian/Campanian age. There is no evidence for the Lower Maastrichtian. The outcrops between the Itongazi and Mpenjati Rivers yield Santonian inoceramids and ammonites.

The presence of Cretaceous rocks beneath Durban was first noted by Anderson (1906 : 48), whilst faunas have been recorded by Krige (1932) and King & Maud (1964), all of whom equate the sequence with the Umzamba Beds. Material from recent excavations indicate the presence of horizons within both the Santonian and the Campanian stages.

North of Durban, Cretaceous sediments in the Lake St Lucia region were first recorded by Griesbach (1871). The principal work in this area was, however, by William Anderson, the one-man Geological Survey of Zululand and Natal. Anderson noted possible subsurface Cretaceous occurrences in the region of what he called the Umlatuzi Lagoon, and described important sections in two areas : along the Mfolozi River and Umkwelane Hill, and along the Mzinene River and its tributaries. He also noted the occurrence of Cretaceous deposits as far north as the junction of the Ingwavuma and Pongola Rivers (1907 : 60–61), whilst Kilian had recorded Aptian sediments across the border in southern Mozambique a few years previously (Kilian 1902a–c ; see also Krenkel 1910a–c, 1911a–b).

Faunas from Umkwelane Hill were described by Etheridge (1904), who compared them with those of the Umzamba Beds of Pondoland (see also Woods 1906 : 337) and the Arialoor and Trichinopoly Groups of Southern India (then regarded as Turonian and Senonian respectively). Crick (1907a : 228) recorded a further ammonite, *Mortoniceras umkwelanense* Crick, and confirmed an Upper Cretaceous age for the deposits ; additional fossils were recorded by R. B. Newton in 1909. No further work was published until Spath (1921a) described a large collection of ammonites made by A. L. du Toit from exposures at and near Umkwelane Hill. On the basis of this material Spath identified the Campanian and Maastrichtian stages as being present in the area. This region was visited during excursion C18 of the 1929

International Geological Congress (du Toit & van Hoepen 1929), and a series of papers describing and discussing the region resulted (Heinz 1930, Besaire 1930, Venzo 1936, Dietrich 1938, Socin 1939, Montanaro & Lang 1937).

Heinz, Besaire and van Hoepen all claimed to recognize Turonian rocks at the base of the sequence, followed by horizons from Coniacian through to Campanian. Rennie (1930) returned to the view that the sequence was equivalent to the Umzamba Beds, accounting for peculiarities in ammonite fauna on the basis of facies differences. Du Toit (1954) suggested a Lower Santonian age for the sequence, whilst Frankel suggested Coniacian to Upper Santonian or Campanian. Our own collecting indicates that horizons from Lower Coniacian to well up into the Campanian are represented, and that Upper Campanian and Maastrichtian sediments are present to the east, beneath the Tertiary and Recent deposits around Monzi.

Early work on the Lake St Lucia and Mzinene region centre around collections made by Anderson (1902–07) and their description by Etheridge (1907) and Crick (1907a, c). Etheridge gave no date to the material he described (although it is undoubtedly an Albian assemblage), but Crick recognized a Cenomanian fauna from the 'north end of False Bay' (later corrected to the junction of the Munywana and Mzinene Rivers), and recorded Upper Albian and Senonian fossils from the Munywana. Spath (1921a) added further records and in addition recognized supposed Coniacian and Campanian forms.

Van Hoepen (1926–66) described a vast number of ammonite species from this part of Zululand, suggested a classification of the succession, and recognized Aptian to Maastrichtian stages, as discussed below (p. 272). His basic views were supported in publications resulting from the 1929 Congress visit (Besaire 1930, Besaire & Lambert 1930, Heinz 1930, Venzo 1936, Socin 1939, Montanaro & Lang 1939). Van Hoepen's systematic work (1929 onwards) suffers from extensive splitting, and the majority of his taxa are synonyms of well-established classic genera and species (see, for instance, Haas 1942, Wright 1957).

Since van Hoepen's work, little has been published. Muir-Wood (1953) described a single brachiopod from the Mzinene whilst Foraminiferida are noted by Smitter (1957). As already described (Kennedy & Klinger 1971 ; see also p. 268 above), the section in this area is in fact incomplete, and the supposed Maastrichtian of van Hoepen and others is high Campanian.

North of the Mzinene, supposed Turonian sediments were described by van Hoepen *in* du Toit & van Hoepen (1929) from close to the junction of the Mkuze and Msunduzi Rivers, and apparently accepted as such by many other workers (e.g. Besaire 1930, Venzo 1936, Furon 1950, 1963). These beds, said to be characterized by large oysters, are of a Coniacian age, the oysters coming from the overlying Tertiary. Still further north, there are excellent accounts of sections along streams draining east from the Lebombos to the Pongola River by Haughton (1936a) and Boshoff (1945), and some molluscs from the area were described by Rennie (1936). Unfortunately, the rich ammonite faunas (Haughton 1936b, Spath 1953) were never described, although horizons from Upper Aptian to Upper Albian were recognized. Some additional information is provided by Spath (1925), Dietrich (1938), and Haughton (1969).

No horizons higher than the Lower Cenomanian are exposed at the surface in this northernmost part of Zululand, for east of the Pongola the country is a wilderness of drifted sand. Davey (1969) and Pienaar (1969) have, however, described Campanian to Palaeocene microfloras from a deep borehole in the Lake Sibayi region.

## V. STRATIGRAPHIC NOMENCLATURE

Present nomenclature of the Cretaceous deposits of Zululand and Natal is in a far from satisfactory state. The term 'Umzamba Beds' is used for the Santonian and Campanian strata of Southern Natal, whilst to the north, the following terms have been used in the Mzinene–St Lucia region by van Hoepen (1926, 1929) and others:

| | |
|---|---|
| Umzamba Beds | Upper Senonian |
| Itweba Beds | Middle Senonian |
| *Peroniceras* Beds | Lower Senonian |
| Munyuana Beds | Turonian |
| Skoenberg Beds | Cenomanian |
| Umsinene Beds | Albian |
| Ndabana Beds | Aptian/Albian |

These divisons are variously described as 'Beds' or 'Zones' and it is quite clear from van Hoepen's original accounts (1926, 1929) that they are based upon faunal differences, and that, apart from the conglomerate and sandstone units of the Ndabana Beds and the sandy base of the Umsinene Beds, the sequence is of a uniform silt facies.

These divisions are thus neither wholly lithostratigraphic nor biostratigraphic units, nor are they precisely defined in terms of faunas or lithology. We see no need for a local biostratigraphic system, for the internationally recognized stages of the Cretaceous can be recognized in South Africa. We therefore propose the *lithostratigraphic* terminology outlined in Table 1.

TABLE 1

Lithostratigraphic and biostratigraphic subdivisions of the Zululand Cretaceous

| VAN HOEPEN (1926, 1929) | | KENNEDY & KLINGER (herein) | STAGES |
|---|---|---|---|
| Umzamba Beds<br>Itweba Beds<br>*Peroniceras* Beds<br>Munyuana Beds | Zululand Group | St Lucia Formation | Lower Maastrichtian<br>Campanian<br>Santonian<br>Coniacian |
| Skoenberg Beds<br>Umsinene Beds | | Mzinene Formation | Cenomanian<br>Albian |
| Ndabana Beds | | Makatini Formation | Aptian<br>Upper Barremian |
| | | | (pre-Upper Barremian ?) |

We further propose that the Cretaceous sediments developed in Zululand be termed the *Zululand Group*, and that the term 'Umzamba Formation' be retained for the Upper Cretaceous deposits of Pondoland.

Definitions of these lithostratigraphic units are as follows :

### *Zululand Group*

1. *The Makatini Formation.* The type section extends along the Mfongosi Spruit, in northern Zululand, from where the base of the formation rests on Lebombo Volcanics to Loc. 169, 27° 21′ 38″ S, 32° 09′ 57″ E. The succession consists of sandstones, siltstones and conglomerates, with marine Upper Aptian fossils. Details of localities are given on pp. 301–302. To the north, along the Mlambongwenja, the same formation yields Upper Barremian and Aptian marine faunas.

2. *The Mzinene Formation.* The type section extends along the Mzinene River from Loc. 51, 27° 53′ 43″ S, 32° 19′ 22″ E, to Loc. 60, 27° 52′ 45″ S, 32° 20′ 55″ E. The base of the formation is taken at the minor non-sequence and bored concretion bed which separates the Aptian and Albian stages. A complete succession up to and including the lower part of the Upper Cenomanian is represented in this formation, which consists largely of silts with shelly and concretionary horizons. Details of localities are given on p. 288.

3. *The St Lucia Formation* has as its type locality river bank sections along the Mzinene from Loc. 60, 27° 52′ 45″ S, 32° 20′ 55″ E, to its entry into False Bay, and the cliff and foreshore sections around False Bay and Lake St Lucia. The base of the formation is taken at the base of the Coniacian conglomerate exposed at Loc. 60 on the Mzinene (p. 288) : locality details are given on pp. 288–298. The succession consists predominantly of siltstones, with concretionary and shelly horizons. The base of the formation is of Lower Coniacian age ; the highest horizons exposed at the surface yield Lower Maastrichtian ammonites and inoceramid bivalves.

The *Umzamba Formation* has as its type section the cliffs and foreshore exposures north of the mouth of the Umzamba River, 31° 06′ S, 30° 10′ E approximately. The type section ranges in age from high Coniacian to Campanian.

## VI. STAGE LIMITS AND SUBDIVISIONS

All the stages of the Cretaceous present problems of definition, and almost without exception international usage is highly variable. For clarity, we outline here our working definitions of the Barremian to Maastrichtian stages. Since correlation with the European type areas is still not fully possible, and because the European stratotypes still present problems of interpretation, these are 'local' definitions only. We also present our working subdivisions of the stages, although again it must be stressed that all our systematic determinations are provisional. A far more detailed biostratigraphic system will be available when our taxonomic work is complete.

### Barremian

'L'étage Barrémien' was introduced by Coquand in 1862. The type area for the stage is the environs of Barrême, near Digne, Basses-Alpes, France. Busnardo

(1965a) has designated the Angles section close by as stratotype : recent discussions of the stage in its type area are given by Sornay (1957), Busnardo (1965a, b), Guillame & Sigal (1965), Bouché (1965) and Fauré (1965) ; an English summary is given by Middlemiss & Moullade (1970 : 352–354).

We have recognized only Upper Barremian faunas in Zululand, so that the vexing problem of the base of the stage and the position of the *Pseudothurmannia angulicostata* Zone is not relevant here. The Mesogean aspect of much of the fauna of the type Barremian makes direct correlation with our sequence difficult. More relevant is the work of Druzhchitz (1963a, b) on the revision of the Barremian sequence in Georgia, Dagestan and the Northern Caucasus, which clearly demonstrates the uppermost Barremian age of the classic 'Aptian' *Colchidites* faunas of the region described by Rouchadzé (1932), Eristavi (1955), Rengarten (1926) and others. These faunas closely resemble our Zululand material and are the basis for recognition of the Upper Barremian.

### *Barremian I*

Characterized by an abundance of crioceratitids, including a variety of '*Emericiceras*' and '*Acrioceras*'-like forms, hemihoplitids, *Heteroceras*, abundant juvenile aconeceratids, together with large *Sanmartinoceras*-like body chambers, *Phylloceras serum* (Oppel), *Eulytoceras phestum* (Matheron) and occasional *Colchidites*.

### *Barremian II*

Characterized by the occurrence of *Colchidites* (*Colchidites*) in vast numbers, with juvenile aconeceratids locally common. The only other forms recorded are occasional *Sanmartinoceras*, *Phylloceras*, crioceratid-like fragments and indeterminate ancyloceratids.

## Aptian

'L'étage Aptien' was first used by d'Orbigny in 1840 ; the type locality of the stage is around Apt, Vaucluse, in southern France. Sornay (1957) reviews early usage of the name ; the succession in the type area and adjoining regions is discussed by Taxy *et al.* (1965), Moullade (1965a, b) and Flandrin (1965). The most complete review of Aptian biostratigraphy is given by Casey (1961). The classic definition of the Aptian/Barremian boundary is at the appearance of primitive deshayesitids, *Pseudohaploceras matheroni* (d'Orbigny) and *Procheloniceras albrechtiaustriae* (Hoehnneger *in* Uhlig). Of these forms, only early cheloniceratids are known from Zululand, and we have drawn the base of the Aptian below their first occurrence. Subdivisions of the stage are as follows :

### *Aptian I*

Juvenile cheloniceratids, tentatively referred to *Procheloniceras*, are abundant. The only other ammonites known are *Tropaeum* sp., *Ancyloceras* sp. and other ancyloceratid fragments.

*Aptian II*

*Cheloniceras* s.s. becomes frequent, and includes forms resembling *Cheloniceras gottschei* (Krenkel) and *C.* aff. *proteus* Casey, together with larger specimens having *Procheloniceras*-like outer whorls. A desmoceratid (*Valdedorsella* or *Pseudohaploceras*) is not uncommon, as are large, poorly preserved ancyloceratids, e.g. *Ancyloceras, Tropaeum* and *Australiceras.*

Above this level there may be a non-sequence.

*Aptian III*

Characterized by an abundance of diverse *Acanthoplites* species, *Diadochoceras* ?, *Valdedorsella, Phylloceras,* diverse small heteromorphs including *Ancyloceras, Protanisoceras*-like and *Tonohamites*-like forms, and *Lytoceras.*

*Aptian IV*

Characterized by an abundance of giant *Tropaeum,* especially finely-ribbed forms. Large '*Lytoceras*' are common, together with *Tonohamites,* giant *Acanthoplites, Diadochoceras nodostocatum* (d'Orbigny) and related forms.

## Albian

'L'étage Albien' was introduced by d'Orbigny in 1842. The type area of the stage is Aube, Roman Alba, in southern France. Sornay has reviewed previous usage and interpretation of the stage (1957), whilst Lower Albian stratigraphy is revised by Casey (1961), the Middle Albian reviewed by Owen (1971) and sections in the type area and adjacent regions described by Larcher *et al.* (1965), Destombes & Destombes (1965), Marie (1965) and Collignon (1965).

The subdivision of much of the type Albian is based upon the typically boreal hoplitids, which did not range into southern Africa, and as a result correlation with Europe, especially during the Middle Albian, is difficult. We follow Breistroffer (1947) and Casey (1961) in placing the 'Clansayes' horizon in the Aptian, taking the base of the Albian as the base of the European *Leymeriella tardefurcata* Zone. In Zululand, as in Madagascar (Collignon 1965), this basal part of the Albian is missing, and the Aptian/Albian boundary is a non-sequence (Kennedy & Klinger 1972), the local base of the Albian being marked by the abundance of *Douvilleiceras.* Subdivisions of the stage are as follows :

*Albian I* – absent

*Albian II*

Abundant *Douvilleiceras,* including forms close to *D. orbignyi* Spath, *D. mammillatum* (Schlotheim) and varieties. Other ammonites are scarce, but include poorly preserved desmoceratids and lytoceratids.

*Albian III*

*Douvilleiceras* is abundant, but in contrast to Albian II, diverse other ammonites occur. A *Damesites*? sp. nov. is common, whilst *Lyelliceras* species, including *L. lyelli* (d'Orbigny) and *L. pseudolyelli* (Parona & Bonarelli) are frequent, together with '*Neosilesites*', *Phylloceras* (*Hypophylloceras*), '*Beaudanticeras*', '*Cleoniceras*' and '*Sonneratia*' species, *Rossalites, Ammonoceratites*, abundant *Anagaudryceras sacya* (Forbes), *Eubrancoceras* aff. *aegoceratoides* (Steinmann) and *Oxytropidoceras* species.

*Albian IV*

*Oxytropidoceras* is common, including subgenera *O.* (*Oxytropidoceras*), *O.* (*Manuaniceras* and *O.* (*Androiavites*). Other ammonites include *Pseudhelicoceras, Mojsisovicsia, Phylloceras* (*Hypophylloceras*) *velledae* (Michelin) and desmoceratids.

*Albian V*

Characterized by the abundance of mortoniceratids, and the bulk of the faunas described by van Hoepen for his Umsinene Beds come from this broad division. Genera present are: *Hysteroceras* (including *Askoloboceras, Komeceras, Petinoceras* and *Terasceras* van Hoepen), *Oxytropidoceras* (including *Lophoceras* van Hoepen), *O.* (*Tarfayites*), *D.* (*Dipoloceras*) (including *Rhytidoceras, Cechenoceras, Ricnoceras* and *Euspectoceras* van Hoepen), *D.* (*Diplasioceras*), *M.* (*Mortoniceras*), *M.* (*Deiradoceras*), *Erioliceras, Arestoceras, Cainoceras, Puzosia, Bhimaites, Desmoceras, P.* (*Hypophylloceras*), *Anagaudryceras, Gaudryceras, Tetragonites, Hamites, Anisoceras, Labeceras* and *Myloceras*.

*Albian VI*

Characterized by the appearance of *Mortoniceras* (*Durnovarites*) species, together with *Stoliczkaia* species including *S. africana* (Pervinquière), *S. notha* (Seeley) and *S. dorsetensis* (Spath), together with abundant *Idiohamites, Hamites* and *Anisoceras* species, with scarcer *Lechites, Mariella, Hypengonoceras* and puzosiids.

## Cenomanian

'L'étage Cenomanien' was introduced by d'Orbigny (1847, 1850, 1852) with the environs of Le Mans, Roman Cenomanum, as the type area. Sornay (1957) has reviewed the history of various usages of the term whilst Hancock (1959) lists the ammonite faunas of the type area and other localities in Sarthe. Kennedy & Hancock (1971) have discussed the problem of the supposed *martimpreyi* Zone at the base of the stage, whilst the higher parts of the stage are discussed by Juignet *et al.* (1973).

The base of the Cenomanian is drawn at the base of the classic *Mantelliceras mantelli* Zone of Hancock (1959), Kennedy (1969–71) and others. It is marked by the diversification of the Mantelliceratinae; genera such as *Mantelliceras, Sharpeiceras, Graysonites, Utaturiceras* and *Acompsoceras* appear, as does *Hypoturrilites*, whilst *Schloenbachia* becomes abundant in the Boreal Realm. In South Africa, we draw the base of the stage at the incoming of abundant *Sharpeiceras* and *Mariella oehlerti* (Pervinquière). Subdivisions of the stage are as follows :

*Cenomanian I*

Characterized by abundant *Sharpeiceras* especially *S. florencae* Spath and *S. falloti* (Collignon), abundant *Mariella oehlerti*, together with scarcer *Desmoceras latidorsatum* (Michelin), *Sciponoceras roto* Cieśliński, *S.* (*Scaphites*) cf. *simplex* Jukes-Browne ?, *Mariella, Ostlingoceras, Hypoturrilites* and *Mantelliceras*.

*Cenomanian II*

Characterized by a rather more diverse assemblage, *Ostlingoceras rorayensis* (Collignon) is common with *Hypoturrilites carcitanensis* (Matheron), *H. gravesianus* (d'Orbigny), *H. tuberculatus* (Bosc), *H. nodiferus* (Crick), *Mariella* spp., *Sciponoceras roto* Cieśliński, *Scaphites* sp., *Desmoceras latidorsatum, Tetragonites subtimotheanus* Wiedmann, *Forbesiceras largilliertianum* (d'Orbigny), *Sharpeiceras laticlavium* (Sharpe) and *Mantelliceras* spp. including *M. spissum* Collignon, *M.* group of *cantianum* Spath, *M. patens* Collignon, *M. indianense* Hyatt and a number of desmoceratids.

*Cenomanian III*

*Turrilites acutus* Passy is abundant, with scarcer *T. costatus* Lamarck and *T. scheuchzerianus* Bosc. Abundant *Acanthoceras* spp., including the forms described by Crick (1907a) as *A. flexuosum* Crick, *A. crassiornatum* Crick, *A. munitum* Crick, *A. robustum* Crick, *A. quadratum* Crick, *A. hippocastanum* Crick (*non* Sowerby) and *A. latum* Crick, occur in the lower part of the division, being replaced above by abundant *Calycoceras* of the *choffati* (Kossmat) group, e.g. *C. newboldi newboldi* Crick (*non* Kossmat ?), *C. newboldi spinosum* Crick (*non* Kossmat ?), *C. newboldi planecostata* Crick (*non* Kossmat ?) and *C. laticostatum* Crick. Other ammonites are *Acanthoceras cornigerum* Crick, *Forbesiceras largilliertianum* d'Orbigny, *F. sculptum* Crick, *Calycoceras gentoni* (Brongniart) *paucinodatum* (Crick) and species of *Desmoceras, P.* (*Hypophylloceras*), *Borissiakoceras, Anisoceras, Stomohamites, Sciponoceras, Scaphites, Puzosia* and *Bhimaites*.

*Cenomanian IV*

Sparsely fossiliferous ; *Calycoceras* of the *choffati* group persists, whilst other ammonites are *Calycoceras nitidum* (Crick), *C.* group of *naviculare* (Mantell) and *Eucalycoceras* sp.

The highest parts of the Cenomanian are absent on land in South Africa.

## Turonian

'L'étage Turonien' was introduced by d'Orbigny in 1842, and amended to its present limits by him in 1847 and 1850. The type area of the stage is Touraine, Roman Turonia, between Saumur and Montrichard, France.

Sornay (1957) has reviewed the history of the various usages of the stage, whilst the problems associated with the definition of the base of the Turonian are discussed by Juignet *et al.* (1973) and Kennedy & Juignet (1973). The base of the stage is taken as the base of the classic *Inoceramus labiatus/Mammites nodosoides* Zone for the purpose of discussion here, although no Turonian rocks are known on land in South Africa.

## Coniacian

'L'étage Coniacien' was introduced by Coquand (1857) with the suburbs of the town of Cognac in Charente, France, as the type area. Here, the stage consists of rather poorly fossiliferous calcarenites (Séronie-Vivien 1959, Dalbiez 1959 : 862). The base of the stage is taken as being at the base of the classic *Barroisiceras haberfellneri* Zone of de Grossouvre (1901), the fauna of which is better known in the Craie de Villedieu of Touraine (de Grossouvre 1894, 1900), where *Barroisiceras, Tissotia, Peroniceras* and other early texanitids typify the Zone.

*Barroisiceras*, well known in the lowest Coniacian of Madagascar (e.g. Basse 1947, Collignon 1965), are absent in our faunas, and it may be that the lowermost Coniacian is absent in South Africa. Instead, our lowest Coniacian yields a sparse fauna of Collignon's (1965) Middle Coniacian *Kossmaticeras theobaldianum* and *Barroisiceras onilahyense* Zone whilst our higher faunas contain elements typical of this zone and his Lower Coniacian *Peroniceras dravidicum* Zone. Our provisional subdivisions of the stage are as follows :

### *Coniacian I*

*Proplacenticeras* are abundant including forms named *P. kaffrarium* (Etheridge), *P. subkaffrarium* (Spath) and *P. umkwelanense* (Etheridge), all of which represent no more than a single variable species. Other ammonites are *Kossmaticeras theobaldianum* (Stoliczka), *Bostrychoceras indicum* (Stoliczka), *Pachydesmoceras denisonianum* (Stoliczka), and *P.* sp.

### *Coniacian II*

*Proplacenticeras* are again abundant, with strongly ornamented *kaffrarium* and *subkaffrarium* more frequent than below. Evolute *Peroniceras* of the *tridorsatum* (Schlüter) group are common, e.g. forms named by van Hoepen as *P. besairei* van Hoepen (= *Fraudatoroceras besairei* van Hoepen) and *P. tenuis* van Hoepen. *Forresteria* are common, e.g. *F. alluaudi* (Boule, Lemoine & Thévenin), *F. razafiniparyi* Collignon, *F. vandenbergi* van Hoepen, *F. reymenti* van Hoepen and *F. hammersleyi* van Hoepen, all of which represent no more than a single variable species ; other ammonites are '*Eedenoceras*' *multicostatum* van Hoepen, *Forresteria itwebae* van Hoepen, *Basseoceras krameri* van Hoepen, *Kossmaticeras sparsicosta* (Kossmat), *K. sakondryense* Collignon, *Puzosia* spp., *Pachydesmoceras* sp., *Lewesiceras australe* van Hoepen, *L.* spp., *Yabeiceras* spp., *Pseudoxybeloceras matsumotoi* Collignon, *Hyphantoceras reussianum* (d'Orbigny), *Allocrioceras* spp., *Baculites bailyi* Woods, *Scaphites meslei* de Grossouvre and *S.* spp.

*Coniacian III*

*Placenticeras* are common, as below, as are coarsely ornamented peroniceratids, e.g. van Hoepen's *P.* (*Zuluiceras*) : *P.* (*Z.*) *zulu* van Hoepen, *P.* (*Z.*) *charlei* van Hoepen and their allies (perhaps no more than a single variable species) ; *Protexanites* (*Protexanites*), *P.* (*Miotexanites*) and *Paratexanites* (*Paratexanites*) species, *Baculites bailyi*, *Kossmaticeras* and *Praemuniericeras* ? sp.

*Coniacian IV*

*Baculites* of the *capensis* group are abundant, whilst compressed, finely ornamented peroniceratids, van Hoepen's *Peroniceras* (*Zuluites*) and robustly ornamented *Gauthiericeras* ?, e.g. *'Falsebayites' peregrinus* van Hoepen, *'Fluminites' albus* van Hoepen, *'Hluhluweoceras' fugitivum* van Hoepen and *'Andersonites' listeri* van Hoepen, are locally common.

*Coniacian V*

The highest Coniacian is not well exposed in Zululand. Above the rather distinctive association of Coniacian IV are beds with abundant *Baculites* ornamented only by growth striae, and also yielding ammonites resembling *Pseudoschloenbachia primitiva* Collignon, and *Scaphites*. This appears to be the horizon of *Subprionotropis cricki* (Spath).

## Santonian

'L'étage Santonien' was introduced by Coquand (1857). The type area is around the village of Saintes in the northern part of the Aquitaine Basin. The position of the base of the stage is disputed (see, for instance, Collignon 1959, Wiedmann 1959, 1964, Dalbiez 1959). The classic ammonite zonation of the stage (de Grossouvre 1894, 1901) is :

*Placenticeras syrtale* Zone
*Eupachydiscus isculensis* Zone
*Texanites texanus* Zone

This is based upon the Corbières succession in southern France ; typical forms of the *texanus* Zone in addition to the index species include *Parabehavites serratomarginatus* (Redtenbacher) and *Muniericeras lapparenti* de Grossouvre. In South Africa we have drawn the base of the stage at the level of the appearance of *Texanites* s.s. in numbers. Subdivisions are :

*Santonian I*

*Texanites oliveti* (Blanckenhorn), *T.* (*Plesiotexanites*) *stangeri* (Baily) *densicosta* (Spath), *T.* (*P.*) *stangeri sparcicosta* Spath, *Hauericeras gardeni* (Baily), *Pseudoschloenbachia* sp., *Pseudophyllites indra* (Forbes), *Karapadites* ? sp., *Eupachydiscus* ? sp., *Gaudryceras* spp., *Hyphantoceras* sp., and diplomoceratids.

*Santonian II*

Abundant *Texanites* (*Plesiotexanites*) *stangeri* and varieties, *T. soutoni* (Baily), *T.* spp., *Hauericeras* and *Pseudoschloenbachia* occur, as do *Eupachydiscus* ?, *Hyphantoceras* and diplomoceratids.

*Santonian III*

*Hauericeras gardeni* is abundant ; the remainder of the fauna is as in Santonian II and is relatively scarce.

## Campanian

'L'étage Campanien' was first used by Coquand in 1857. The type area of the stage is in Grand Champagne, in the Aubeterre (Charente) region of Aquitaine. There are considerable problems associated with the succession in the type area, and the interpretation of the base of the stage used here is taken from de Grossouvre's (1901) synthesis of the French ammonite succession, e.g. at the base of the *Diplacmoceras bidorsatum* Zone. The correlation of the European sequence with South Africa is tenuous, and we have drawn the local base of the stage below the level of abundant *Submortoniceras*. Subdivisions are :

*Campanian I*

*Submortoniceras woodsi* (Spath) and related forms are common ; other ammonites include *Bevahites* and *Menabites*, *Hauericeras gardeni*, *Pseudoschloenbachia*, *Bostrychoceras* and diplomoceratids.

(There may be an unexposed interval in the lithological and faunal sequence at this level.)

*Campanian II*

The texanitid *Menabites* (*Australiella*) is abundant in the lower part of this division, but species including *M.* (*A.*) *australis* (Besaire) and *M.* (*A.*) *besairei* (Collignon) appear to range throughout, together with *Bevahites* species. *Baculites sulcatus* (Baily) (= *Baculites vagina* var. *Van Hoepeni* (Venzo)) is abundant throughout whilst pachydiscids become common in the higher part of the sequence, e.g. *Anapachydiscus subdulmensis* (Venzo), *A. wittekindi* (Schlüter), *A. arialoorensis* (Stoliczka), *Pachydiscus manambolensis* Basse. Other ammonites are *Hoplitoplacenticeras plasticum plasticum* Paulcke, *Maorites* sp., *Neogaudryceras* sp., *Gaudryceras* sp., *Bostrychoceras* sp.

*Campanian III*

Faunas are sparse, but highly distinctive. A feebly nodose *Baculites* is abundant, and giant (up to 1 m) pachydiscids (probably *Eupachydiscus*) are very common.

*Campanian IV*

*Saghalinites cala* (Forbes) and *P.* (*Pachydiscus*) are common. Other ammonites are : *Gunnarites antarticus* (Weller), *Nostoceras* ? sp., and *Pachydiscus* (*Neodesmoceras*) sp.

*Campanian V*

Giant *Bostrychoceras* are abundant, with scarcer *Saghalinites* and compressed pachydiscids.

## Maastrichtian

The term 'Calcaire de Maastricht' was first used by Omalius d'Halloy in 1808, but stratigraphic definition of the stage dates from the work of Dumont (e.g. 1850). The concept of the stage has changed greatly subsequently, and Dumont's Maastrichtian is equivalent to what is now regarded as Upper Maastrichtian. We have thus followed current European practice, and taken the base of the stage as below the *Pachydiscus neubergicus* Zone. It is not at present possible to correlate directly between the classic European sequence and our South African one ; we have therefore drawn the local base of the Maastrichtian below the appearance of abundant *Eubaculites*. Our subdivisions of the stage are as follows :

*Maastrichtian I*

Feebly ornamented to smooth *Eubaculites* are abundant. Other ammonites are *Saghalinites*, *Pachydiscus* (*Neodesmoceras*), *Menuites*, '*Epiphylloceras*' and *Hoploscaphites*.

*Maastrichtian II*

Coarsely ornamented baculitids of *Eubaculites ootacodensis* (Stoliczka) type are abundant. Pachydiscids are also present.

*Maastrichtian III*

No ammonites. Inoceramid debris abundant.

## VII. LOCALITY DETAILS

Detailed logs and stratigraphic accounts plus locality maps for sections studied are deposited in the Palaeontology Library of the British Museum (Natural History). Outline locality details only are given for all but the most important sections in the following pages. Latitude and longitude are given in every case.

### A. Pondoland

Loc. 1. Cliff and foreshore exposures 1 km north of the mouth of the Umzamba River, Northern Transkei, 31° 05′ 50″ S, 30° 10′ 30″ E. Umzamba Formation.

Age. The base of the formation is high in the Coniacian (Coniacian V ?) as indicated by the presence of *Subprionotropis cricki* (Spath) (= *Barroisiceras umzambiensis* van Hoepen) in the Basement Bed. The occurrence of abundant *Pseudoschloenbachia umbulazi*, *Hauericeras gardeni*, *Texanites soutoni*, *Texanites stangeri* and *Inoceramus expansus* (Baily) at various levels above this indicate that horizons up to at least Santonian III, and possibly Campanian I, are present.

Locs 2, 3. Reefs exposed at low water around Trafalgar Beach, between the Mhlangamkulu and Mpenjati Rivers, Southern Natal (Pondoland), 30° 57′ 50″ S, 30° 18′ 00″ E. Umzamba Formation.
AGE. Loc. 2 lies close to the base of the succession and yielded abundant Santonian *Sphenoceramus*. Loc. 3, higher in the succession, is probably Campanian, yielding *Kossmaticeras* (*Natalites*) and *Baculites sulcatus*. *Pseudoschloenbachia umbulazi* has been recorded from this area (Crick 1907b, Spath 1922a).

### B. DURBAN

Loc. 4. Excavations for the new Magistrates' Court on Sometsu Road, Durban. Umzamba Formation.
AGE. Campanian II ? It seems likely that more than one horizon is represented in the collection.

Loc. 5. Excavations for the new sugar terminal at Maydon Wharf, Durban Bay. Umzamba Formation.
AGE. Santonian III and Campanian I ? Several horizons are clearly represented.

### C. KWA-MBONAMBI, ZULULAND

Loc. 6. Excavations (1971) for new bridge over the Nyokaneni River, west of the Mtubatuba–Empangeni road, south of Empangeni, 28° 41′ 14″ S, 32° 01′ 22″ E. St Lucia Formation.
AGE. Santonian II–III, Campanian I.

### D. MFOLOZI AND UMKWELANE HILL, ZULULAND

In this region (Fig. 2), Cretaceous sediments are largely obscured by Tertiary and Quaternary deposits (Fig. 3). Outcrops are limited to strips along the flanks of Lake Teza, followed by the railway (with most exposures in cuttings), and the north bank of the Mfolozi, below Riverview as far east as Monzi.

Locs 7, 8. Small cuttings alongside the track leading from the Mtubatuba Club towards Mains Farm (Frankel 1960 : 236, fig. 3), south of Mtubatuba, 28° 26′ 38″ S, 32° 10′ 20″ E and 28° 26′ 34″ S, 32° 10′ 22″ E respectively. Makatini and St Lucia Formations.
AGE. The Makatini conglomerates and sandstones at these localities cannot be dated more precisely than Lower Cretaceous. The base of the St Lucia Formation is Lower Coniacian, probably Coniacian II.

Loc. 9. Railway cutting 100 m north of Lake View siding, 28° 29′ 18″ S, 32° 08′ 45″ E, on the western side of Lake Teza, south of Mtubatuba. St Lucia Formation. These cuttings expose the contact between the Cretaceous and metamorphic and granitic Basement. The contact is sharp, with a basal Cretaceous conglomerate with boulders of granite and schist up to 30 cm long, set in a matrix of bioclastic limestone. Above are 3 m of hard shelly limestone with softer lenticles, both crowded with oysters, cidarid spines and plates.
AGE. Coniacian.

Loc. 10. Railway cutting 1·1 km north of Haig Halt, 28° 27′ 40″ S, 32° 09′ 58″ E on the eastern flank of Umkwelane Hill, south of Mtubatuba. St Lucia Formation. This is locality d of du Toit (*in* Spath 1921a), also mentioned by Besaire (1930 : 619) and others. The St Lucia Formation, dipping eastwards at 1° to 2°, rests on an undulating surface of deeply-weathered basalt dipping 70° S. The base of the sequence is a tough, buff, sandy and silty limestone, with scattered quartz and quartzite pebbles, abundant oysters, other molluscs and cidarid spines. Perhaps 20 m of alternations of deeply weathered silts and layers of intensely hard concretions with drifted shelly lenticles are exposed above this. There is a diverse molluscan fauna, dominated by bivalves and gastropods. Concretions 3 m above the base yielded *Proplacenticeras umkwelanense*, *Forresteria alluaudi* and a scaphitid. Besaire (1930 : 619, 634, pl. 26, fig. 4) described a *Peroniceras*

from this locality, and Spath records *Proplacenticeras subkaffrarium*, *Diaziceras tissotiaeforme* Spath and other species.
AGE. The presence of *Proplacenticeras* suggests a Coniacian age for the base of the sequence.

LOC. 11. Road cut on the north side of the new road from road N 14 to Haig Halt, Umkwelane Hill, south of Mtubatuba, 20° 28′ 22″ S, 32° 09′ 32″ E. St Lucia Formation.
AGE. The presence of *Proplacenticeras* suggests a Coniacian age for the sequence.

LOC. 12. A small quarry 300 m SSE of the previous section, south of the road and north of the railway near Haig Halt, Umkwelane Hill, south of Mtubatuba, 28° 28′ 31″ S, 32° 09′ 34″ E. St Lucia Formation.
AGE. Coniacian.

LOC. 13. Hill slopes below Riverview Compound, 750 m north of the Cane Railway Bridge across the Mfolozi, south of Mtubatuba, 28° 26′ 52″ S, 32° 10′ 48″ E. St Lucia Formation.
AGE. Coniacian II–III; as indicated by species of *Proplacenticeras*, *Peroniceras*, *Forresteria*, *Scaphites*, *Baculites*, kossmaticeratids, puzosiids and diplomoceratids.

LOC. 14. Road cuttings below the compound immediately south of the Msunduzi River, 2·1 km NNE of Mfolozi, south of Mtubatuba, 28° 28′ 24″ S, 32° 10′ 43″ E. St Lucia Formation.
AGE. Santonian II and III, Campanian I.

LOC. 15. Small quarry east of track on lot 71 13567, 1200 m east of Riverview Sugar Mill, south of Mtubatuba, 28° 26′ 35″ S, 32° 11′ 24″ E. St Lucia Formation.
AGE. Coniacian IV.

LOC. 16. Small quarry 175 m SSE of loc. 15; 28° 26′ 42″ S, 32° 11′ 25″ E. St Lucia Formation.
AGE. Coniacian III ?

LOC. 17. Cuttings in cane road leading down to Peaston North Bank Drain on lot 72 13569, 350 m south of the farm Pasina, SE of Mtubatuba, 28° 26′ 04″ S, 32° 11′ 48″ E. St Lucia Formation.
AGE. Coniacian V.

LOC. 18. Outcrops in cane road leading down to Peaston North Bank Drain on lot 47 12967, 1200 m SE of the farm Chelmsford, ESE of Mtubatuba, 28° 26′ 38″ S, 32° 12′ 38″ E. St Lucia Formation.
AGE. Santonian.

LOC. 19. Road cutting west of Lake Mfuthululu on Shire Estate, leading down to Peaston North Bank Drain, ESE of Mtubatuba, 28° 25′ 39″ S, 32° 14′ 45″ E. St Lucia Formation.
AGE. Campanian I.

LOC. 20. Section at junction of the old course of the Mfolozi, the present river and the unnamed stream draining south from Lake Mfuthululu, ESE of Mtubatuba, 28° 26′ 59″ S, 32° 16′ 36″ E. St Lucia Formation.
AGE. Maastrichtian I–II.

LOC. 21. Roadside section 9 km north of Monzi, east of Mtubatuba, 28° 25′ 00″ S, 32° 18′ 35″ E. St Lucia Formation.
AGE. Campanian V.

### E. THE NYALAZI RIVER, SOUTH OF HLUHLUWE, ZULULAND

North of Mtubatuba, exposures are poor, due to an extensive cover of Tertiary and Recent deposits. Such sections as are visible are deeply decalcified and often barren of recognizable macrofossils. There are, however, a series of exposures along the Nyalazi River which give a discontinuous sequence from Karoo sediments and Lebombo Volcanics through to the St Lucia Formation.

Loc. 22. Cut on the north side of the Nyalazi River, east of the old Nyalazi road and railway bridge, 2 km north of the Nyalazi River Trading Store, 28° 12′ 23″ S, 32° 18′ 02″ E. St Lucia Formation.
Age. Coniacian IV.

Loc. 23. Stream exposures 1·4 km NW of the old Nyalazi bridge, 28° 12′ 05″ S, 32° 17′ 01″ E. St Lucia Formation.
Age. Coniacian III ?

Loc. 24. Cuttings and excavations at the new Nyalazi River bridge in Moroval 1884 section, 28° 14′ 27″ S, 32° 17′ 37″ E. St Lucia Formation.
Age. Coniacian II–V.

Loc. 25. Cutting alongside new road 2·8 km ESE of Nyalazi River trading store, 28° 13′ 42″ S, 32° 16′ 48″ E. St Lucia Formation.
Age. Coniacian II.

Loc. 26. River banks on NE side of the Nyalazi, 1 km ENE of the old combined road/rail bridge 28° 12′ 12″ S, 32° 18′ 42″ E. St Lucia Formation.
Age. Santonian ?

Loc. 27. Trackside exposures leading down to the eastern bank of the Nyalazi 1·25 km SE of the old bridge, 28° 12′ 35″ S, 32° 18′ 44″ E. St Lucia Formation.
Age. Campanian I.

Loc. 28. Abandoned quarry on southern side of Nyalazi River trading store–Charters Creek track 1·3 km east of the store, 28° 13′ 12″ S, 32° 19′ 10″ E. St Lucia Formation. Scattered exposures of Campanian silts occur for several kilometres along the Nyalazi downstream of this locality.
Age. Campanian.

Loc. 29. Excavations by abandoned dam on Cekeni Estate 2·9 km ESE of Mfekayi Halt, 28° 10′ 54″ S, 32° 20′ 05″ E. St Lucia Formation.
Age. Campanian I–II.

Loc. 30. Overgrown hill slopes on the western side of the Nyalazi River in Bantu Reserve No. 3, 5 km east of Glenpark Estate, 28° 07′ 52″ S, 32° 20′ 56″ E. St Lucia Formation.
Age. Campanian I–II.

Loc. 31. Gullies and hill slopes on west bank of Nyalazi in Bantu Reserve No. 3, 6 km ENE of Glenpark Estate, 28° 07′ 12″ S, 32° 21′ 47″ E. St Lucia Formation.
Age. Santonian.

### F. Glenpark Estate, Zululand

Sections along the lower Hluhluwe are poor, but exposures along the railway on Glenpark Estate prove definitely the presence of Albian sediments. Cenomanian faunas are unknown, but there is a very complete Coniacian sequence exposed to the NE (p. 295). Although not proven, the base of the St Lucia Formation may rest upon Upper Albian Mzinene Formation in this area.

Loc. 32. Cutting in acute bend of railway west of Glenpark Estate, 11 km south of Hluhluwe, 28° 07′ 55″ S, 32° 17′ 18″ E. Mzinene Formation.
Age. Albian III.

Loc. 33. Railway cuttings west of Glenpark Estate, 11 km south of Hluhluwe, 28° 07′ 50″ S, 32° 17′ 39″ E. Mzinene Formation.
Age. Albian IV.

## G. The Mzinene River and its tributaries, Zululand

### (i) Upper reaches

The Mzinene and its tributaries provide a discontinuous succession from the Lebombo Volcanics and pre-Upper Aptian clastics of the Makatini Formation to the Upper Coniacian and perhaps Lower Santonian St Lucia Formation. It is the type section of the Mzinene Formation and the base of the succeeding St Lucia Formation.

Sections along the tributary streams are poor, and those along the main river are usually below water, because of extensive damming. Bilharzia and crocodiles (see du Toit and van Hoepen 1929) render these sections rather inaccessible, but extensive droughts prior to our visit had reduced water levels and raised salinities so much that we were able to see far more of this section than is usually exposed, and collect important faunas from the lower parts of the Upper Albian.

Dips in this area are low, of the order of 2°–6°, and it is difficult to measure the thickness of the sequence when exposures are limited to the stream bed. Cliff exposures are available, but are often deeply weathered and choked by thorn and scrub. Some additional exposures are available in old river cliffs, as at the Skoenberg, and south of the kraal in Ndabana 13162 section, but these are deeply decalcified and the fossil fauna lies loose on hill slopes.

Loc. 34. Cliff and stream section 600 m north of the farm Amatis, just to NE of the confluence of the Mzinene and an un-named, eastward-flowing tributary, north of Hluhluwe, 27° 58′ 32″ S, 32° 18′ 02″ E. Makatini Formation.
Age. Aptian IV.

Loc. 35. Cliff and stream sections extending over several hundred metres along the Mzinene, approximately 1200 m NE of the farm Amatis, north of Hluhluwe, 27° 58′ 03″ S, 32° 18′ 31″ E. Mzinene Formation.
Age. Albian III.

Loc. 36. Degraded river cliff on the eastern bank of the Mzinene close to the boundary of lots H 84 14107 and H 85 14108, north of Hluhluwe, 27° 57′ 14″ S, 32° 18′ 34″ E. Mzinene Formation.
Age. Albian III.

Loc. 37. Discontinuous exposures in the bed of the Mzinene over a distance of some 600 m in lots H 86 13655 and H 87 13656, north of Hluhluwe, 27° 56′ 37″ S, 32° 18′ 08″ E. Makatini Formation.
Age. Aptian IV.

Locs 38–43. North of loc. 37, the Mzinene swings west in a long meander, crossed by the road running east from the National Road N 14, just north of Ngweni. In this region, there are a series of exposures in the Makatini Formation, with hills of Lebombo Volcanics rising to the east. Makatini Formation.

Loc. 38. 27° 56′ 09″ S, 32° 18′ 03″ E.
Loc. 39. 27° 55′ 57″ S, 32° 17′ 44″ E (Plate, Fig. 1).
Loc. 40. 27° 55′ 58″ S, 32° 17′ 58″ E.
Loc. 41. 27° 55′ 42″ S, 32° 17′ 50″ E.
Loc. 42. 27° 55′ 38″ S, 32° 17′ 02″ E.
Loc. 43. 27° 55′ 20″ S, 32° 18′ 10″ E.

Age. Pre-Upper Aptian. No ammonites or other diagnostic fossils are known.

Loc. 44. Stream section 900 m SE of Baboon's Krans, north of Hluhluwe, 27° 54′ 24″ S, 32° 17′ 48″ E.
Age. Pre-Upper Albian.

Locs 45–49. Stream and river cliff exposures extending downstream from the drift where the minor road leading north from the sisal factory to Monte Rosa crosses the Mzinene, 27° 53′ 59″ S, 32° 18′ 06″ E to 27° 53′ 50″ S, 32° 19′ 10″ E. Makatini Formation.
Age. Pre-Upper Aptian.

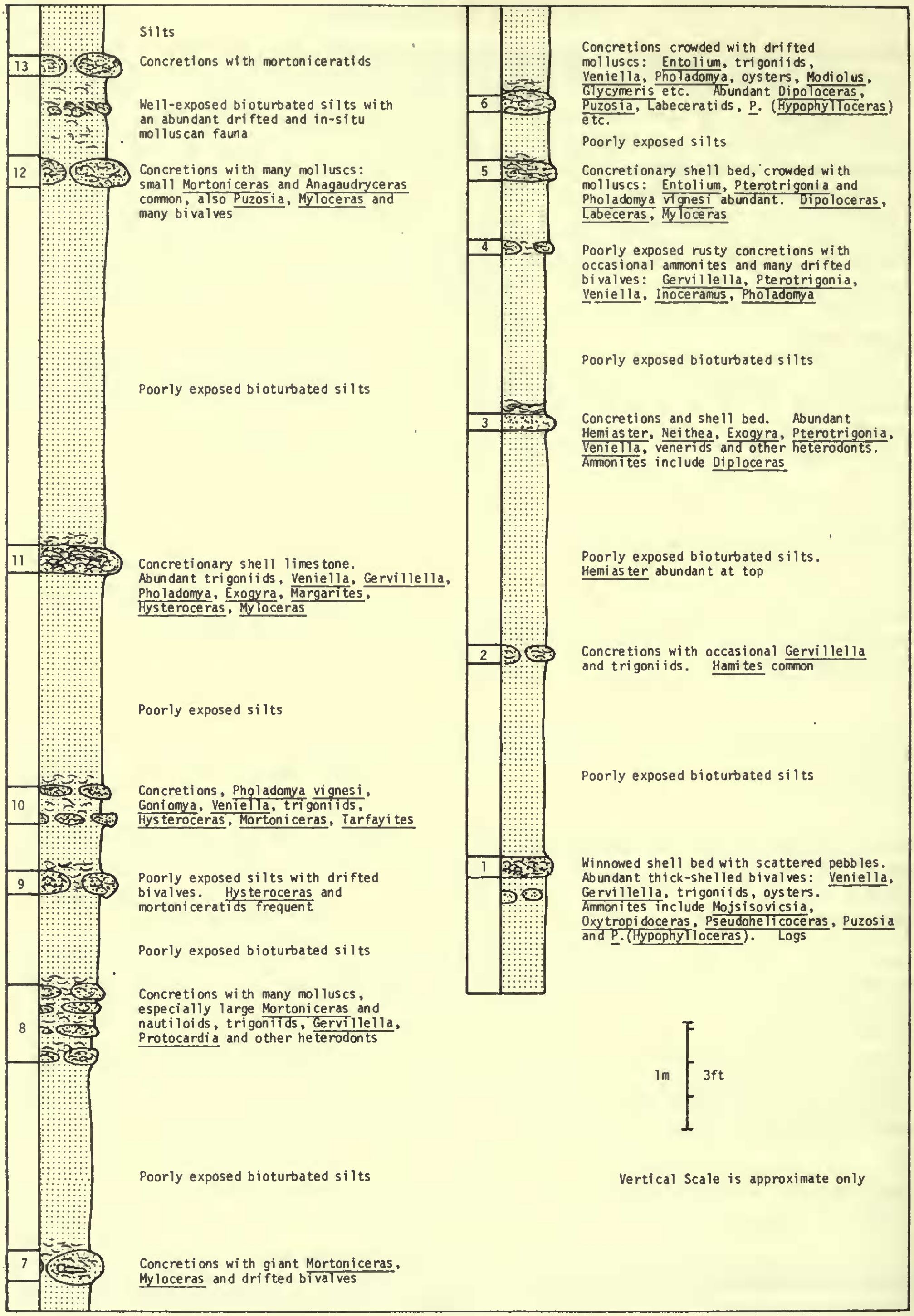


FIG. 4. The sequence at loc. 51.

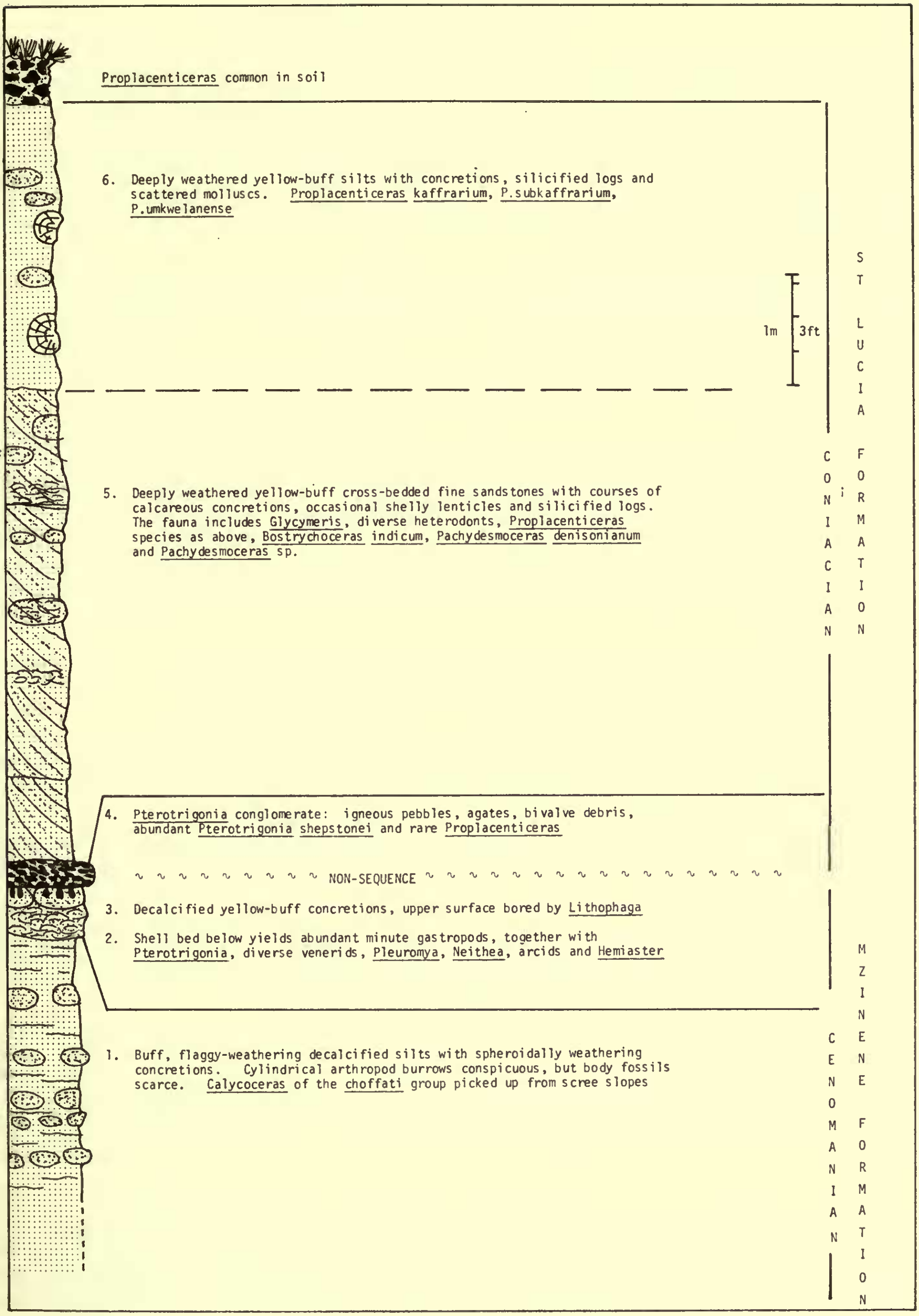


Fig. 5. The sequence at loc. 60.

Loc. 50. Outcrops in the river bed north of the earth dam 1200 m ENE of the sisal factory, where the track to the farm Belvedere approaches the Mzinene, north of Hluhluwe, 25° 53′ 50″ S, 32° 19′ 10″ E. Makatini Formation.
Age. Aptian.

Loc. 51. Stream bed and bank exposures extending 100–600 m downstream from loc. 50, around the eastern limb of the broad meander ENE of the sisal factory, north of Hluhluwe, 27° 53′ 43″ S, 32° 19′ 22″ E (Fig. 4). Mzinene Formation.
Age. Albian IV–V.

Loc. 52. West bank of the Mzinene just north of a gully entering from the west in Indabana 13162 section, north Hluhluwe, 27° 53′ 04″ S, 32° 19′ 21″ E. Mzinene Formation.
Age. Albian V.

Loc. 53. Derelict dam site on Indabana 13162, 2·2 km south of the farm Izwehelia, north of Hluhluwe, 27° 52′ 24″ S, 32° 19′ 02″ E. Mzinene Formation.
Age. Albian III.

Loc. 54. Degraded river cliff 200–350 m west of south-trending gully which joins the Mzinene in Munywana 13161 section, close to where the river turns sharply eastwards north of Hluhluwe, 27° 52′ 46″ S, 32° 19′ 40″ E. Mzinene Formation.
Age. Albian V.

Loc. 55. Sections in the gully immediately east of the previous locality, 500 m north of its junction with the Mzinene in Munywana 13161 section, 27° 52′ 26″ S, 32° 19′ 42″ E. Mzinene Formation.
Age. Albian V.

Loc. 56. Degraded river cliffs immediately east of loc. 55, in Munywana 13161 section, 27° 52′ 30″ S, 32° 19′ 44″ E. Mzinene Formation.
Age. Albian V.

Loc. 57. Outcrops in the bed of the Mzinene at Beacon 624, where the river swings east in Munywana 13809 section, north of Hluhluwe, 27° 52′ 40″ S, 32° 19′ 58″ E. Mzinene Formation.
Age. Albian V.

Loc. 58. Degraded cliff on the north bank of the Mzinene in Iswelihle 13163 section WNW of the farm Belvedere, NNE of Hluhluwe, 27° 52′ 42″ S, 32° 20′ 36″ E. Mzinene Formation.
Age. Albian V.

Loc. 59. Section on eastern side of swamp at the mouth of a gully draining south to the Mzinene from the Skoenberg in Iswelihle 13163 section, 1200 m NNW of the farm Belvedere, NNE of Hluhluwe, 27° 52′ 41″ S, 32° 20′ 45″ E. Mzinene Formation.
Age. Cenomanian III.

Loc. 60. River cliff and river bed outcrops extending for several hundred metres along the north side of the Mzinene in Iswelihle 13163 section, 1000 m NNW of the farm Belvedere, north of Hluhluwe, 27° 52′ 45″ S, 32° 20′ 55″ E (Fig. 5). Mzinene and St Lucia Formations.
Age. Mzinene Formation : Cenomanian III–IV ; St Lucia Formation : Coniacian I.

### (ii) The Skoenberg region

The Skoenberg, in Iswelihle 13163, NNW of Hluhluwe, is a crescentic hill lying between the Mzinene and Munywana (Manuan of early workers). The steep NW face rises to over 30 m at the western end ; to the east it falls to the level of the flood plain. It represents an abandoned river cliff of the Munywana, which now flows across the northern part of its flood plain at this point, 700 m from the old cliff.

This is the celebrated locality described by William Anderson in 1907 (p. 60) as situated near the junction of the Manuan and Mzinene Rivers. It is the source of the rich Cenomanian fauna described by G. C. Crick in 1907, and the type locality of van Hoepen's Skoenberg Beds.

The hill itself is capped by a veneer of Pleistocene debris, including dark brown, glazed rock fragments and derived Senonian fossils. The NW cusp of the hill is capped by the Coniacian *Pterotrigonia* conglomerate (Anderson's 1907 : 60 'hard calcareous sandstone full of broken shells'). This dips gently to the east, at first forming the rim to the north face of the Skoenberg, and then crossing down the face to disappear below the alluvium of the Munywana/Mzinene flood plain.

There are good exposures of the silts above and below the conglomerate along the main face of the Skoenberg, whilst to the west gullies and hill slopes provide a magnificent series of exposures, extending down to the Upper Albian. These correspond to localities 5–8 of van Hoepen (1966a, b).

Loc. 61. Hill slopes and gullies west of the western 'horn' of the Skoenberg, 27° 52′ 19″ S, 32° 20′ 19″ E (Fig. 6). Mzinene Formation.
AGE. Albian VI–Cenomanian II.

Loc. 62. Hill slopes at, and extending west from, the western end of the Skoenberg, 27° 52′ 17″ S, 32° 20′ 26″ E (Fig. 7). Mzinene and St Lucia Formations.
AGE. Mzinene Formation : Cenomanian II–IV ; St Lucia Formation : Coniacian I.

Loc. 63. The steep, northern face of the scarp of the Skoenberg, 27° 52′ 15″ S, 32° 20′ 30″ E. St Lucia Formation.
AGE. Coniacian I.

### (iii) Sections along the Munywana

In Munywana 13161 section, NNE of Hluhluwe, Zululand.

Loc. 64. River cliff on the south side of the main southern tributary of the Munywana, 1·5 km ESE of the farm Izwehelia, 27° 51′ 36″ S, 32° 19′ 41″ E. Mzinene Formation.
AGE. Albian V.

Loc. 65. Dam site excavation and adjacent hillside 200–300 m west of the previous locality and 1300 m SW of the farm Izwehelia, 27° 51′ 38″ S, 32° 19′ 30″ E. Mzinene Formation.
AGE. Albian V.

Loc. 66. River-bed and cliff sections extending for some 400–500 m along the northern branch of the Munywana north of a point 1·5 km east of the farm Izwehelia and just south of a group of native huts, 27° 51′ 16″ S, 32° 19′ 44″ E. Mzinene Formation.
AGE. Albian V.

Loc. 67. Poor exposures in the north bank of the gully 600 m SSW of the farm Izwehelia, 27° 51′ 37″ S, 32° 19′ 01″ E. Mzinene Formation.
AGE. Albian.

Loc. 68. North bank of gully 300 m SW of the farm Izwehelia, 27° 51′ 32″ S, 32° 19′ 03″ E. Mzinene Formation.
AGE. Albian II.

Loc. 69. Densely vegetated outcrop in gully 600 m ESE of the farm Izwehelia, 27° 51′ 29″ S, 32° 19′ 11″ E. Mzinene Formation.
AGE. Albian II.

Loc. 70. Excavations for a dam site 500 m east of the farm Izwehelia, 27° 51′ 20″ S, 32° 19′ 04″ E. Mzinene Formation.
AGE. Albian II.

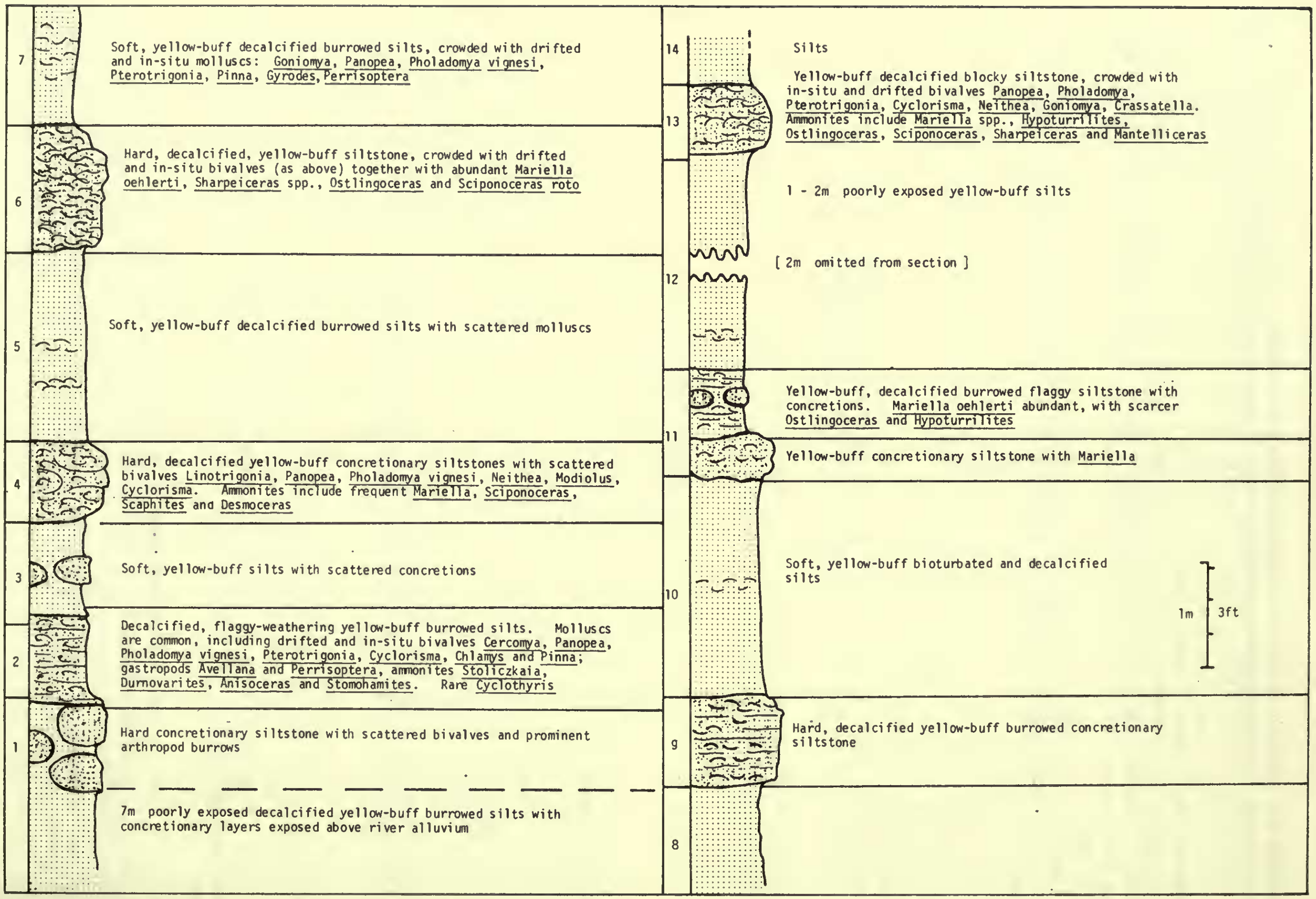


FIG. 6. The sequence at loc. 61.

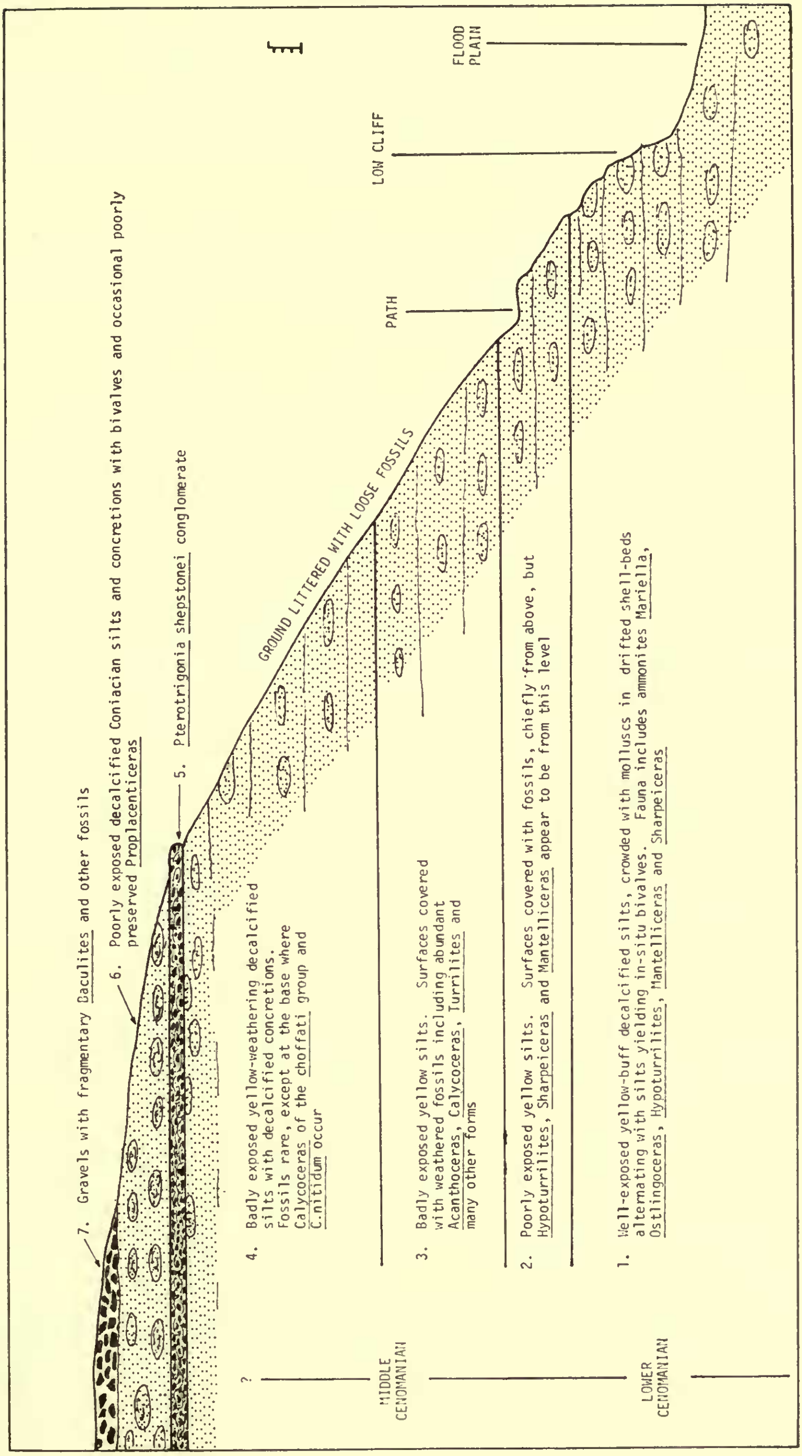


FIG. 7. The sequence at loc. 62.

(iv) Lower reaches

In Umzigi 13809 section, NNE of Hluhluwe, Zululand.

LOC. 71. Degraded river cliffs on the north bank of the Munywana Creek, north of the Skoenberg, 3 km SW of the farm Insleep, and just west of the earth dam 400 m west of the causeway across the Mzinene just below the confluence with the Munywana, 27° 51′ 48″ S, 32° 21′ 08″ E. St Lucia Formation.
AGE. Coniacian I.

LOC. 72. Degraded river cliff and alluvial flats on the north side of the Mzinene, 200–300 m east of the causeway across the river, downstream from its junction with the Munywana, 27° 51′ 52″ S, 32° 21′ 34″ E. St Lucia Formation.
AGE. Coniacian IV–V, Santonian I ?

## H. SECTIONS AROUND FALSE BAY AND LAKE ST LUCIA, ZULULAND

The False Bay and Lake St Lucia Game Reserves form a lagoon 80 km long, separated from the sea by dunes up to 200 m high. The lake is nowhere more than a few metres deep and drains to the sea via the Narrows, 16 km to the south. During drought or when the entrance to the Narrows is blocked, the lake level falls and salinity rises steeply, accompanied by mass mortality of the bulk of the invertebrate fauna. During floods, the lake becomes temporarily freshwater.

Four principal rivers drain into the lake, the Mzinene, Mkuze, Hluhluwe and Nyalazi. Each has an associated swampy flood plain at its mouth, several miles across. The flood plains and the lake itself are flanked by cliffs up to 30 m high. These are, for the most part, degraded and heavily vegetated, but locally expose vertical sections of Cretaceous silts and concretionary horizons over stretches of several hundred metres. Foreshore platforms are cut in the Upper Cretaceous at many localities ; extreme drought during our visit exposed many normally submerged outcrops. Elsewhere, saltmarsh and saline pans extend from degraded cliffs to the lake shore, masking the Cretaceous.

The dip is low, perhaps 3° just south of east, and as a result many exposures approximate to strike sections.

We have been able to collect and measure sections along the western shores of False Bay, around the southern termination of the Nibela Peninsula, along the SW shores of Lake St Lucia, and around the southern peninsula.

(i) Western False Bay

LOC. 74. 1400 m stretch of cliff and foreshore section at Die Rooiwalle, 1·3 km east of the farm Mfomoto, northern part of False Bay, NNE of Hluhluwe, 27° 54′ 12″ S, 32° 23′ 47″ E to 24° 54′ 48″ S, 32° 23′ 15″ E (Fig. 8). St Lucia Formation.
AGE. Santonian I–Campanian I.

LOCS 75–77. Gullies in degraded cliffs 300 m, 1200 m and 1700 m respectively south of Die Rooiwalle, and inland of an extensive saline pool, NW shores of False Bay, NE of Hluhluwe. St Lucia Formation.
LOC. 75. 27° 54′ 57″ S, 32° 23′ 07″ E. LOC. 77. 27° 55′ 04″ S, 32° 22′ 56″ E.
LOC. 76. 27° 55′ 19″ S, 32° 22′ 49″ E.
AGE. Coniacian V.

LOC. 78. Foreshore platform 4 km north of Lister's Point and 3·1 km east of the farm Onderdeel, NW shores of False Bay, NE of Hluhluwe, 27° 56′ 02″ S, 32° 22′ 54″ S. St Lucia Formation.
AGE. Santonian I–II.

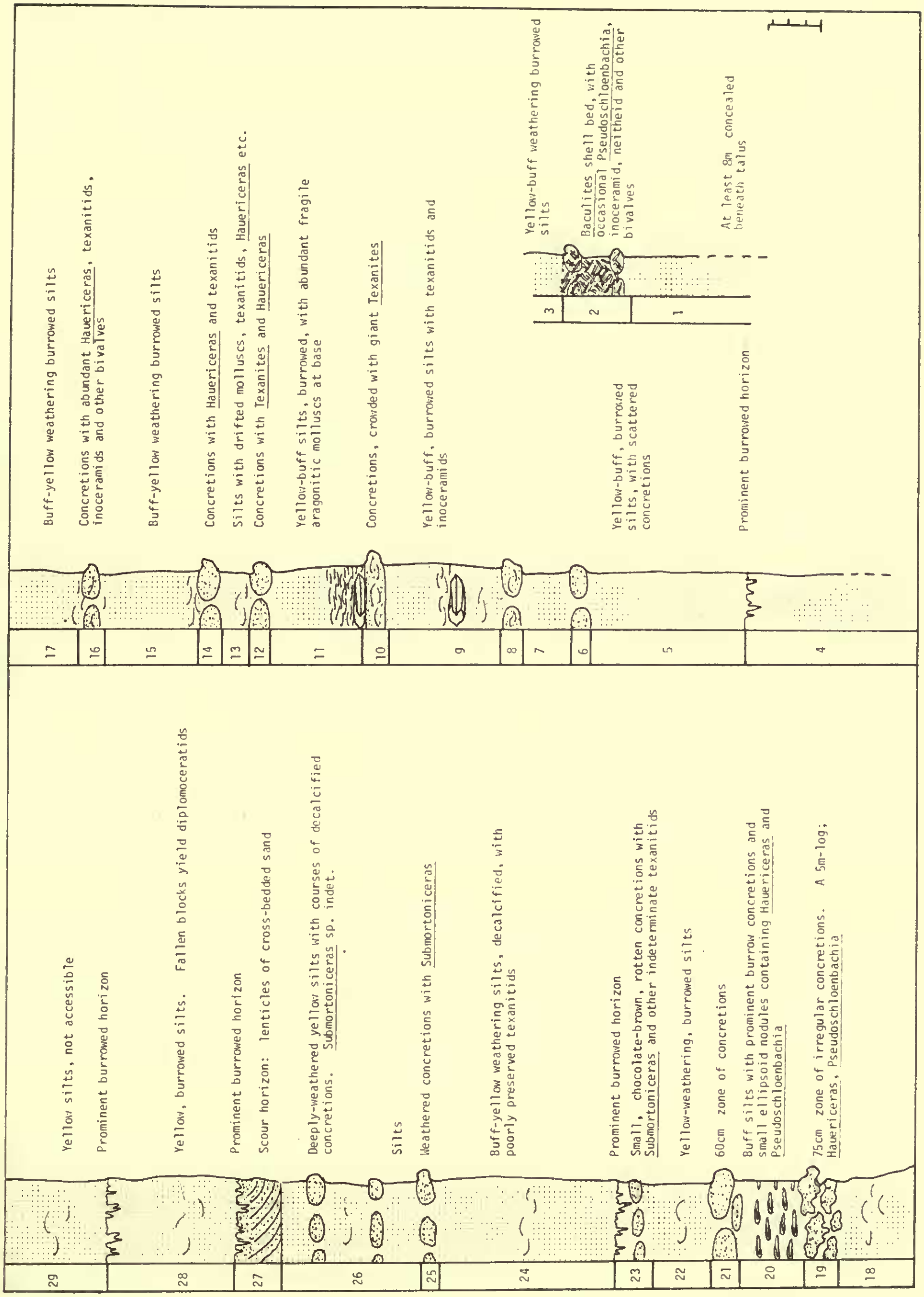


FIG. 8. The sequence at loc. 74.

Loc. 79. Degraded cliff section at the northern end of the coastal track 1700 m north of Lister's Point, NW shores of False Bay, NE of Hluhluwe, 27° 57′ 09″ S, 32° 22′ 36″ E. St Lucia Formation.
Age. Coniacian V.

Loc. 80. Foreshore reefs alongside camp site, 600 m north of Lister's Point, western shores of False Bay, NE of Hluhluwe, 27° 57′ 43″ S, 32° 28′ 38″ E. St Lucia Formation.
Age. Coniacian V.

Loc. 81. Foreshore platforms west of Lister's Point, western shores of False Bay, NE of Hluhluwe, 27° 58′ 14″ S, 32° 27′ 26″ E. St Lucia Formation.
Age. This locality extends across the strike. Faunas from the western outcrops are undoubtedly Coniacian IV–V. To the east, higher horizons may be present.

Loc. 82. Foreshore platforms at the end of the small promontory 1·3 km SW of Lister's Point, western shores of False Bay, NE of Hluhluwe, 27° 58′ 38″ S, 32° 22′ 20″ E. St Lucia Formation.
Age. Coniacian IV.

Loc. 83. Foreshore exposures extending around the headland 3·5 km north of Picnic Point and known locally as Mason's Camp, western shores of False Bay ENE of Hluhluwe, 28° 00′ 18″ S, 32° 22′ 20″ E. St Lucia Formation.
Age. Coniacian IV.

Loc. 84. Beach exposures and low cliff 3·2 km north of Picnic Point, SW shores of False Bay, east of Hluhluwe, 28° 01′ 00″ S, 32° 22′ 08″ E. St Lucia Formation.
Age. Santonian I.

Loc. 85. Low cliff and foreshore exposures extending from 1200 to 1800 m north of Picnic Point, SW shores of False Bay, east of Hluhluwe, 20° 01′ 17″ S, 32° 22′ 08″ E. St Lucia Formation.
Age. Santonian I.

Loc. 86. Line of concretions striking across the foreshore 750 m north of Picnic Point, SW shores of False Bay, east of Hluhluwe, 28° 01′ 45″ S, 32° 22′ 03″ E. St Lucia Formation.
Age. Coniacian V–Santonian I or II.

### (ii) The Hluhluwe flood plain

South of Picnic Point, the alluvial flats of the Hluhluwe extend out into False Bay, and there are no major exposures for several miles down the coast. Instead, outcrops are limited to poor sections and loose boulders along the river cliffs on the sides of the Hluhluwe. This area is of some importance, being the type locality of van Hoepen's (1926 onwards) *Peroniceras* Beds, and the source of many Coniacian ammonites described by him (1966a–c). The cliffs run oblique to the strike, and progressively lower horizons appear to the SW.

(a) *Western side*

Loc. 87. Boulders and concretions littering hill slopes just east of the point where the track to Picnic Point descends to the flood plain of the Hluhluwe, ESE of Hluhluwe Village, 28° 02′ 10″ S, 32° 21′ 55″ E. St Lucia Formation.
Age. Santonian I.

Loc. 88. Loose boulders and concretions littering slopes over a radius of 200 m from 150 m west of the point where the track to Picnic Point descends to the flood plain of the Hluhluwe, ESE of Hluhluwe Village, 28° 02′ 12″ S, 32° 21′ 40″ E. St Lucia Formation.
Age. Coniacian IV–V, perhaps also Santonian I ?

Locs 89, 90. Boulder- and concretion-strewn slopes east and west respectively of the gully 250 m east of the western boundary of the St Lucia Game Reserve, ESE of Hluhluwe Village, 28° 02′ 16″ S, 32° 21′ 19″ E to 28° 02′ 20″ S, 32° 21′ 11″ E. St Lucia Formation.
AGE. Coniacian IV.

Loc. 91. Degraded river cliffs and artificial cut extending over 200 m west of the boundary fence of the St Lucia Game Reserve and lot H 103 13368, ESE of Hluhluwe Village, 28° 02′ 21″ S, 32° 21′ 02″ E. St Lucia Formation.
AGE. Coniacian IV or V.

Loc. 92. Bulldozer scrapings and adjacent hill slopes around the pumping station at the southern end of the track leading south from the farm Panplaas, on lot H 102 13364, ESE of Hluhluwe Village, 28° 03′ 07″ S, 32° 20′ 10″ E. St Lucia Formation.
AGE. Coniacian II and III.

Loc. 93. Hill slopes extending 200 m on either side of the boundary fence of lots H 102 13364 and H 101 3046, 1600 m SE of the farm Ncedomhlope, ESE of Hluhluwe Village, 28° 03′ 19″ S 32° 20′ 00″ E. St Lucia Formation.
AGE. Coniacian II.

(b) *Eastern side*

Locs 94–96. Shore outcrops SE of the end of the track running north of Nkundusi, ESE of Hluhluwe, 28° 03′ 50″ S, 32° 21′ 46″ E. St Lucia Formation.
AGE. Coniacian V and Santonian I.

Loc. 97. Cliff section 2 km NE of Nkundusi, SE of Hluhluwe, 28° 04′ 42″ S, 32° 22′ 32″ E. St Lucia Formation.
AGE. Santonian.

Loc. 98. Hill slopes alongside track leading north from Nkundusi, 2·0–2·3 km north of the village, SE of Hluhluwe, 28° 04′ 12″ S, 32° 21′ 14″ E. St Lucia Formation.
AGE. Coniacian V ?

Loc. 99. Hill slopes alongside the track running north from Nkundusi, 1·0–1·5 km north of the village, SE of Hluhluwe, 28° 04′ 37″ S, 32° 21′ 26″ E. St Lucia Formation.
AGE. Coniacian V.

Loc. 100. Hill slopes alongside track leading north from Nkundusi, 1·3 km north of the village, SE of Hluhluwe, 28° 04′ 47″ S, 32° 21′ 27″ E. St Lucia Formation.
AGE. Santonian I.

Loc. 101. Slopes 250 m south of loc. 100, 28° 04′ 57″ S, 32° 21′ 26″ E. St Lucia Formation.
AGE. Santonian II or III.

### (iii) False Bay : SE shores

Loc. 102. Cliff exposure at SE end of False Bay east of Nkundusi, and SE of Hluhluwe, 28° 05′ 18″ S, 32° 23′ 02″ E. St Lucia Formation.
AGE. Campanian I or II ?

Loc. 103. Hill slopes 1·6 km NNE of the mouth of the Nyalazi, SE of Hluhluwe, 28° 04′ 42″ S, 32° 23′ 37″ E. St Lucia Formation.
AGE. Campanian II ?

Loc. 104. Cliff and foreshore exposures 2·3–2·7 km NNE of the mouth of the Nyalazi, SE of Hluhluwe, 28° 04′ 12″ S, 32° 23′ 38″ E. St Lucia Formation.
AGE. Santonian II.

Loc. 105. Cliff section 3·5 km north of the mouth of the Nyalazi, ESE of Hluhluwe, 28° 03′ 27″ S, 32° 23′ 08″ E. St Lucia Formation.
Age. Santonian III to Campanian I.

Loc. 106. Cliffs 4·2 km north of the mouth of the Nyalazi, ESE of Hluhluwe, 28° 03′ 06″ S, 32° 23′ 16″ E. St Lucia Formation.
Age. Campanian I.

Loc. 107. Loose concretions on shore 400 m north of loc. 106, ESE of Hluhluwe, 28° 02′ 45″ S, 32° 23′ 26″ E. St Lucia Formation.
Age. Campanian ?

Loc. 108. Foreshore exposures 6 km north of the mouth of the Nyalazi, east of Hluhluwe, 28° 02′ 21″ S, 32° 23′ 32″ E. St Lucia Formation.
Age. Campanian I.

(iv) The Nibela Peninsula

This area is a Native Reserve, access is restricted, and we have only visited the southern coast. For long stretches this is a dip section across interbedded silts and concretions dipping at approximately 3° just south of east. Exposures consist of vertical cliffs up to 25 m high, capped by Miocene(?) and Pleistocene sediments, and broad foreshore exposures.

From the SW corner of the peninsula, and running northwards, the cliffs are degraded. We have not examined this area, rather relying on material in the South African Survey (van Hoepen Collection), nor have we examined the eastern side.

Loc. 109. Foreshore exposures at the SW tip of the Nibela Peninsula, 27° 59′ 03″ S, 32° 24′ 36″ E. St Lucia Formation.
Age. Campanian II.

Loc. 110. 150 m stretch of cliff and foreshore section at the SW tip of the Nibela Peninsula, 27° 59′ 10″ S, 32° 24′ 34″ E (Fig. 9). St Lucia Formation.
Age. Campanian III.

Loc. 111. Cliff section just east of the southernmost tip of the Nibela Peninsula, 27° 59′ 30″ S, 32° 25′ 26″ E. St Lucia Formation.
Age. Campanian III.

Loc. 112. Foreshore exposures 1·4 km north of Hell's Gate, Nibela Peninsula, 27° 58′ 47″ S, 32° 25′ 49″ E. St Lucia Formation.
Age. Campanian III.

Loc. 113. Cliff section at the SE corner of the Nibela Peninsula, 27° 58′ 12″ S, 32° 26′ 57″ E. St Lucia Formation.
Age. Campanian IV–V.

(v) The Southern Peninsula

Loc. 114. Foreshore exposures at the NW tip of the peninsula, 28° 00′ 51″ S, 32° 24′ 44″ E. St Lucia Formation.
Age. Campanian II.

Loc. 115. Foreshore exposures NW of Lake Pisechene, 28° 01′ 03″ S, 32° 25′ 32″ E. St Lucia Formation.
Age. Campanian III.

Loc. 116. Cliff section NE of Lake Pisechene, 28° 01′ 06″ E, 32° 26′ 04″ E. St Lucia Formation.
Age. Campanian IV.

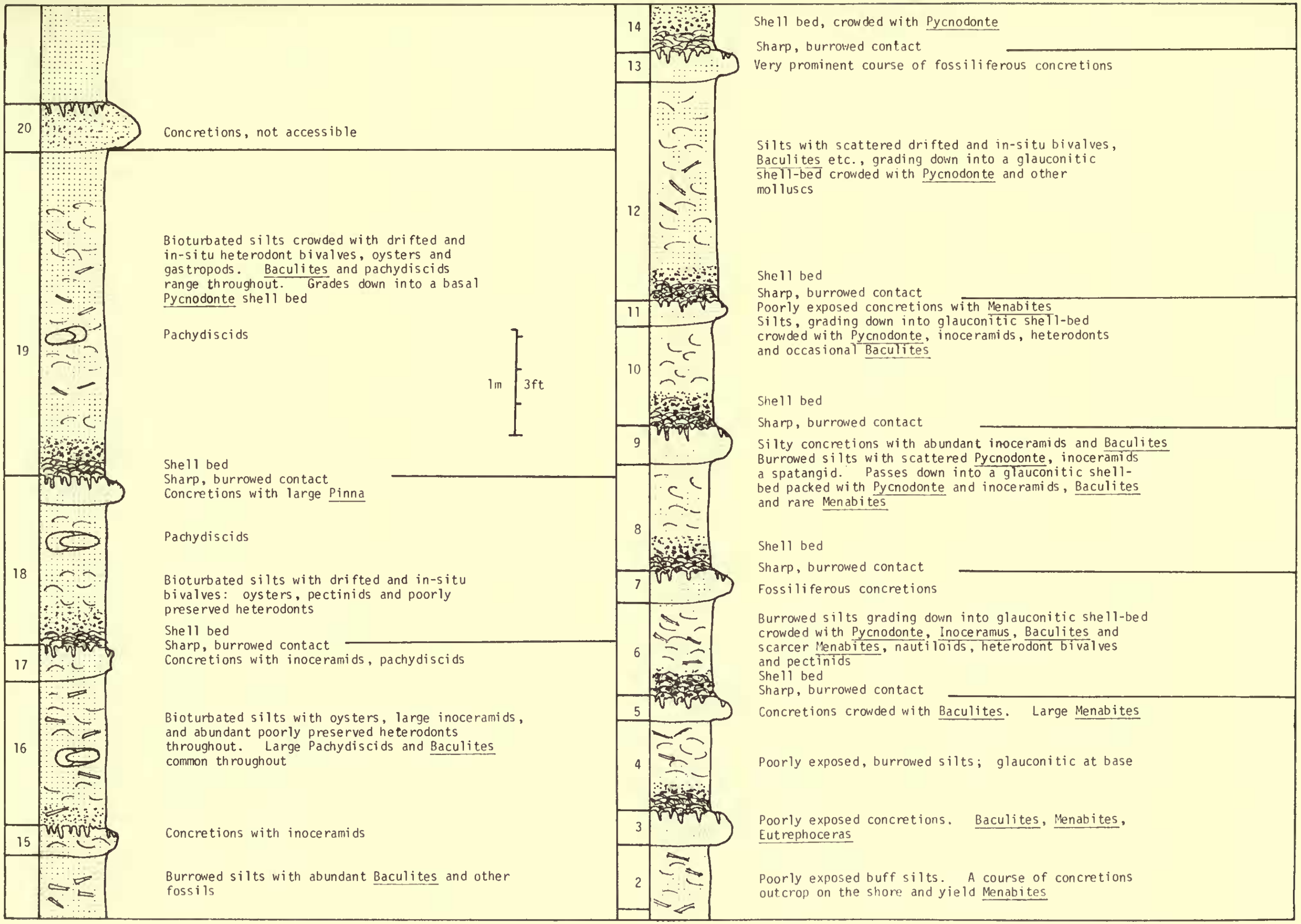


FIG. 9. The sequence at loc. 110.

Loc. 117. Beach exposures at Hell's Gate, the extreme NE tip of the peninsula, 28° 00′ 36″ S, 32° 26′ 48″ E. St Lucia Formation.
Age. Campanian IV.

(vi) Lake St Lucia

Locs 118–121. The Coves, and cliff sections for 2 km to the north and 3 km to the south, eastern shores of the Southern Peninsula. St Lucia Formation.

Loc. 118. 28° 00′ 58″ S, 32° 26′ 49″ E.
Loc. 119. 28° 02′ 48″ S, 32° 26′ 47″ E.
Loc. 120. 28° 03′ 23″ S, 32° 26′ 27″ E.
Loc. 121. 28° 03′ 57″ S, 32° 26′ 32″ E.

Age. Campanian III–IV.

Locs 122–125. Foreshore platforms 1200, 1600, 1900 and 2200 m north of Fanies Island Camp, eastern shores of the Southern Peninsula. St Lucia Formation.

Loc. 122. 28° 05′ 39″ S, 32° 26′ 22″ E.
Loc. 123. 28° 05′ 19″ S, 32° 26′ 25″ E.
Loc. 124. 28° 04′ 57″ S, 32° 26′ 25″ E.
Loc. 125. 28° 04′ 40″ S, 32° 26′ 30″ E.

Age. Campanian III–IV.

Loc. 126. Foreshore exposure 700 m south of the shore track leading south from Fanies Island Camp, 28° 07′ 27″ S, 32° 25′ 56″ E. St Lucia Formation.
Age. Maastrichtian II.

Loc. 127. Foreshore exposures 1·8 km south of Fanies Island Camp, 28° 07′ 40″ S, 32° 25′ 56″ E. St Lucia Formation.
Age. Maastrichtian.

Loc. 128. Cliff and foreshore exposures 2·7 km south of Fanies Island Camp, 28° 08′ 02″ S, 32° 25′ 58″ E. St Lucia Formation.
Age. Maastrichtian III.

Locs 129, 130. Cliff and shore sections from 4·4 to 5·2 km south of Fanies Island Camp, 28° 08′ 59″ S, 32° 25′ 47″ E to 28° 09′ 23″ S, 32° 25′ 41″ E. St Lucia Formation.
Age. Maastrichtian III.

Loc. 131. Low cliff and foreshore section 3·1 km north of Charter's Creek Rest Camp, 28° 09′ 53″ S, 32° 25′ 37″ E. St Lucia Formation.
Age. Maastrichtian II.

Loc. 132. Degraded cliff and shore platform 300 m NE of the northern jetty at Charter's Creek Rest Camp, 28° 11′ 32″ S, 32° 25′ 17″ E. St Lucia Formation.
Age. Maastrichtian I.

Loc. 133. Cliff section and beach platforms below Charter's Creek Rest Camp, 28° 12′ 38″ S, 32° 28′ 08″ E. St Lucia Formation.
Age. Maastrichtian I.

Loc. 134. Cliffs and foreshore 1·2 km south of Charter's Creek Rest Camp, 28° 12′ 59″ S, 32° 25′ 08″ E. St Lucia Formation.
Age. Maastrichtian I.

Loc. 135. Foreshore outcrops in Makakatana Bay, east of the village, 28° 13′ 51″ S, 32° 25′ 08″ E. St Lucia Formation.
Age. Maastrichtian I.

### J. The Mkuze River and its tributaries

North of Lake St Lucia, the coastal plain east of the Lebombo Mountains is covered by Miocene to Pliocene marine sediments and Pleistocene to Recent dune sands. Exposures of the Cretaceous are very poor, and are restricted to cliffs and pans along the Mkuze and its tributaries.

Scattered exposures show Lebombo Volcanics overlain by conglomeratic Makatini Formation with marine Upper Aptian fossils at the summit. Above the Aptian/Albian non-sequence, Albian rocks are well exposed, and to the west there are isolated outcrops of Coniacian and Santonian sediments.

### (i) Southern part of Mkuze Game Reserve

Loc. 136. Banks of rivulet west of the road leading to the mine, 27° 44′ 08″ S, 32° 16′ 50″ E. Makatini Formation.
Age. Pre-Aptian ?

Loc. 137. Trackside exposures 1·5 km NNW of the old Msunduze drift along the road leading to the mine, 27° 44′ 25″ S, 32° 16′ 54″ E. Makatini Formation.
Age. Aptian ?

Loc. 138. Rivulet 800 m NE of the landing strip on Nxala Estate, 27° 43′ 06″ S, 32° 16′ 38″ E. Makatini Formation.
Age. Aptian IV.

Loc. 139. Roadside section and hillside on Nxala Estate 2·3 km NNE of Mt Nxala, 27° 41′ 18″ S, 32° 15′ 30″ E. Makatini Formation.
Age. Aptian IV.

Loc. 140. Large working quarry south of road and west of Nsumu Pan, 27° 40′ 16″ S, 32° 15′ 18″ E. Makatini Formation.
Age. Aptian IV.

Loc. 141. Hill slopes 750 m NNE of the previous locality. 27° 39′ 52″ S, 32° 15′ 22″ E. Makatini Formation.
Age. Aptian IV.

Loc. 142. Hillside east of track leading to the mine, 27° 44′ 24″ S, 32° 17′ 12″ E. Makatini and Mzinene Formations.
Age. Aptian IV ? ; Albian III.

Loc. 143. Small outcrops east of road by unnamed pan 3 km north of drift over Msunduze, 27° 43′ 12″ S, 32° 17′ 20″ E. Mzinene Formation.
Age. Albian III.

Loc. 144. Low ridge on SW side of Nsumu Pan at mouth of unnamed northwards-flowing rivulet, 27° 41′ 19″ S, 32° 17′ 50″ E. Mzinene Formation.
Age. Albian V.

### (ii) The Morrisvale Area

Loc. 145. Degraded cliffs on the eastern side of the Msunduzi, 3 km SW of the farm Morrisvale, north of Ngweni, 27° 42′ 28″ S, 32° 20′ 56″ E. St Lucia Formation. This locality extends for several hundred metres, with a few metres of silts and concretions sporadically exposed in the steep slopes between the flood plain and lowest terrace of the Msunduzi. The locality is of great importance, for it represents one of the sections which van Hoepen (1926, 1929) and others (e.g. Furon 1963) recognized as Turonian, and is said to be characterized by large oysters. In fact, the Cretaceous sequence is capped by a basal conglomerate and limestone rubble of Miocene(?) age, which yields the oysters, in turn capped by Pleistocene sands. The Cretaceous rocks are poorly exposed, but loose boulders and excavations reveal richly fossiliferous horizons, crowded with bivalves, both drifted and in life position. One level of concretions is crowded with ammonites, especially *Proplacenticeras*, together with scarcer *Yabeiceras*, *Forresteria*, *Peroniceras* and nautiloids.
Age. Coniacian II.

Loc. 146. Quarry 1·71 km NW of the farm Morrisvale, on the south bank of the Mkuze, east of its junction with the Msunduzi, 27° 40′ 36″ S, 32° 22′ 03″ E. St Lucia Formation.
Age. Santonian.

Loc. 147. Hill slopes in the Bantu area 4 km north of the confluence of the Mkuze and Msunduze, north of Ngweni, 27° 38′ 23″ S, 32° 22′ 22″ E. St Lucia Formation.
Age. Santonian.

### (iii) Mantuma Rest Camp Area

Loc. 148. River cliff on west bank of Mkuze due east of Ndlelakufa Pan, 27° 34′ 55″ S, 32° 11′ 50″ E. Makatini Formation.
Age. Aptian or pre-Aptian.

Loc. 149. Southern cliffs of Nhlohlela Pan, 2 km west of Mantuma Camp, 27° 35′ 38″ S, 32° 12′ 05″ E. Makatini Formation.
Age. Aptian or pre-Aptian.

Loc. 150. Cliff section on southern side of Nhlohlela Pan, 1·3 km west of Mantuma Camp, 27° 35′ 48″ S, 32° 12′ 28″ E. Makatini Formation.
Age. Aptian III–IV.

Loc. 151. Hill slopes on eastern side of Nhlohlela Pan, 1 km WNW of Mantuma Camp, 27° 35′ 28″ S, 32° 12′ 53″ E. Makatini Formation.
Age. Aptian IV.

Loc. 152. Hill slopes south of road leading to Nhlohlela Pan from Denyer's Drift, 500 m west of Mantuma Camp, 27° 35′ 39″ S, 32° 12′ 53″ E. Makatini and Mzinene Formations.
Age. Aptian IV, Albian II–III.

Loc. 153. Site excavations for reservoir in Mantuma Camp, just east of Denyer's Drift, 27° 35′ 36″ S, 32° 13′ 10″ E. Mzinene Formation.
Age. Albian III, IV ?

Loc. 154. Abandoned road metal quarry south of track 500 m east of Mantuma Camp, 27° 35′ 33″ S, 32° 13′ 38″ E. Mzinene Formation.
Age. Albian III–IV ?

Loc. 155. Gully on south side of the Ndlamyane at Gujini, NE of the road leading NW from Mantuma Camp, 27° 32′ 54″ S, 32° 10′ 48″ E. Makatini Formation.
Age. Aptian.

Loc. 156. Bed of Ndlamyane, 600 m downstream from loc. 155, 27° 32′ 42″ S, 32° 11′ 20″ E. Mzinene Formation.
Age. Albian III.

## K. Northern Zululand

This term covers the area from Jozini north to Ndumu, on the Mozambique border. In this region, the crest of the Lebombos rises to more than 600 m, the volcanics dipping east at 2°–3°. Dip slopes descend to the level of the coastal plain, with spurs extending eastwards into the littoral, west of the Pongola.

The coastal plain itself has an average elevation of less than 100 m, rising to 180 m in the Ndumu region. The Cretaceous succession has been truncated by a series of Tertiary transgressions, the deposits of which, together with Pleistocene and Recent dune sands, mask the whole area. Outcropping Cretaceous accounts for less than 1 per cent of the region. Sections are thus confined to areas where streams and gullies draining west from the Lebombos to join the Pongola cut through the Tertiary cover, and a few natural exposures and quarries, chiefly

in the high ground around Ndumu. We have seen no exposures on the littoral, east of the Pongola, nor have we been able to examine sections along the Usutu and in the Ndumu Game Reserve.

(i) Mayezela Spruit

This is Myesa Spruit of Haughton (1936a : 285) ; there are exposures both east and west of the drift on the dirt road from Jozini to Ndumu, 4·2 km NNE of the store at Otobotini.

To the west, platy rhyolites are well exposed, dipping in an easterly direction at about 10°. The base of the Cretaceous is not visible, but on the high ground east of the crossing on the northern branch, buff, coarse sandstones are well exposed.

Loc. 157. Gullies just east of the road, beyond the drift on the north branch of the Mayezela Spruit, 10 km NE of Jozini, 27° 22′ 45″ S, 32° 06′ 43″ E. Makatini Formation.
Age. Pre-Upper Aptian.

(ii) Mfongosi Spruit

Horizons from Lebombo Volcanics through conglomerates and up into marine Aptian and Albian are exposed along this section, which lies 8 km NNE of Otobotini. A valuable account and guide to this section is given by Haughton (1936a : 286), although it must be noted that the present dirt track crosses the spruit 1·5 km east of the track shown by him (1936a : fig. 2).

Cretaceous sediments are exposed in the bed and walls of the deep gully cut by the Mfongosi, and along degraded bluffs, capped by river gravels, both north and south of the present stream bed.

Loc. 158. Cliffs on the north side of the north branch of the Mfongosi, 800 m NW of the drift and 400 m from the junction with the main stream, 27° 21′ 20″ S, 32° 07′ 18″ E. Makatini Formation.
Age. Pre-Upper Aptian.

Loc. 159. Cliff on the south side of the Mfongosi, 100 m NW of the drift, 27° 21′ 30″ S, 32° 04′ 25″ E. Makatini Formation.
Age. Pre-Upper Aptian.

Loc. 160. Cliff on south side of stream, at bend 400 m SE of the drift, 27° 21′ 50″ S, 32° 07′ 45″ E. Makatini Formation.
Age. Pre-Upper Aptian.

Loc. 161. Sheer cliff at the bend of the stream 550 m east of the drift, 27° 21′ 38″ S, 32° 08′ 00″ E. Makatini Formation.
Age. Pre-Upper Aptian.

Loc. 162. Cliff on south side of the stream 1200 m SE of the drift, 27° 21′ 57″ S, 32° 08′ 15″ E. Makatini Formation.
Age. Aptian.

Loc. 163. Cliff on the north side of the stream, just east of the old drift, 27° 21′ 39″ S, 32° 08′ 30″ E. Makatini Formation.
Age. Haughton (1936a : 288) records *Acanthoplites* spp. from this section, which thus appears to be Aptian III.

Loc. 164. River cliff on the north side of the stream, 200 m NE of the old drift, 27° 21′ 36″ S, 32° 08′ 32″ E. Makatini Formation.
Age. Aptian III.

Loc. 165. Cliff and cliff-top exposure on the south side of the stream 450 m SE of the old drift, 27° 21′ 58″ S, 32° 08′ 43″ E. Makatini Formation.
Age. Aptian III.

Locs 166, 167. Bluffs on the north side of the spur running eastwards from loc. 165, 27° 22′ 02″ S, 32° 08′ 53″ E to 27° 22′ 04″ S, 32° 09′ 03″ E. Makatini Formation.
Age. Aptian III (loc. 166) ; Aptian III–IV (loc. 167).

Loc. 168. Bluffs along the ridge on the north side of the stream, 700–1200 m ESE of the old drift, 27° 21′ 43″ S, 32° 09′ 25″ E (Fig. 10). Makatini Formation.
Age. Aptian III–IV.

Loc. 169. Gully and adjacent hill slopes on the north side of the stream 2 km east of the old drift, 27° 31′ 38″ S, 32° 09′ 57″ E (Fig. 10). Makatini and Mzinene Formations.
Age. Aptian IV, Albian II, III.

### (iii) Mlambongwenya Spruit

This stream section (Lombangwena Spruit of Haughton 1936a : 292) lies 20 km NNE of the Mfongosi sections. It is the most important section in Northern Zululand, for it provides the only known exposures of fossiliferous Barremian marine sediments, previously unknown in southern Africa. To the east, around Mlambongwenya Store, there are magnificent sections across the Aptian–Albian boundary.

Loc. 170. Cliff and gully sections 2 km NW of the store, on the north side of the stream, 27° 10′ 10″ S, 32° 10′ 13″ E (Fig. 11). Makatini Formation.
Age. Barremian I–II, Aptian I–II.

Loc. 171. River cliff north of the stream, and hill slopes above, 250 m WSW of the store, 27° 10′ 59″ S, 32° 11′ 08″ E. Makatini and Mzinene Formations.
Age. Aptian IV, Albian II–III.

Loc. 172. Cliff section on the south side of the stream, 100 m west of the drift, 27° 11′ 37″ S, 32° 11′ 25″ E. Makatini Formation.
Age. Aptian IV.

Loc. 173. Steep cliff on the south side of the creek 300 m below the drift, 27° 11′ 37″ S, 32° 11′ 45″ E. Makatini Formation.
Age. Albian II–III.

Loc. 174. Shallow excavations and road sections extending from the store south towards the drift, 27° 11′ 02″ S, 32° 11′ 21″ E. Mzinene Formation.
Age. Albian III.

### (iv) Ndumu

The occurrence of Cretaceous outcrops in the Ndumu region was known already to Anderson (1907 : 61). The area was briefly described by Dietrich (1938), whilst Spath (1925) described a *Sharpeiceras* which we believe to be from this area. Exposures occur along the north bank of the Msunduzi, on hill slopes, south from Ndumu Store to the river, and around the police station ; horizons from low in the Albian to the Lower Cenomanian are exposed (Fig. 12).

Loc. 175. Exposures in and around gully west of the track leading SW from Ndumu, in Impala, 300 m south of Quotho Pan, 26° 56′ 22″ S, 32° 12′ 48″ E. Mzinene Formation.
Age. Albian II–III.

Loc. 176. Slopes south of track and north of Quotho Pan across the boundary of Impala and Wisteria 18122 locations, 26° 55′ 59″ S, 32° 18′ 04″ E. Mzinene Formation.
Age. Albian III.

Loc. 177. Field along the north side of the Msunduzi Pan in Wisteria 18122 location, 2 km SW of Ndumu Store, 26° 56′ 08″ S, 32° 13′ 57″ E. Mzinene Formation.
Age. Albian IV–V.

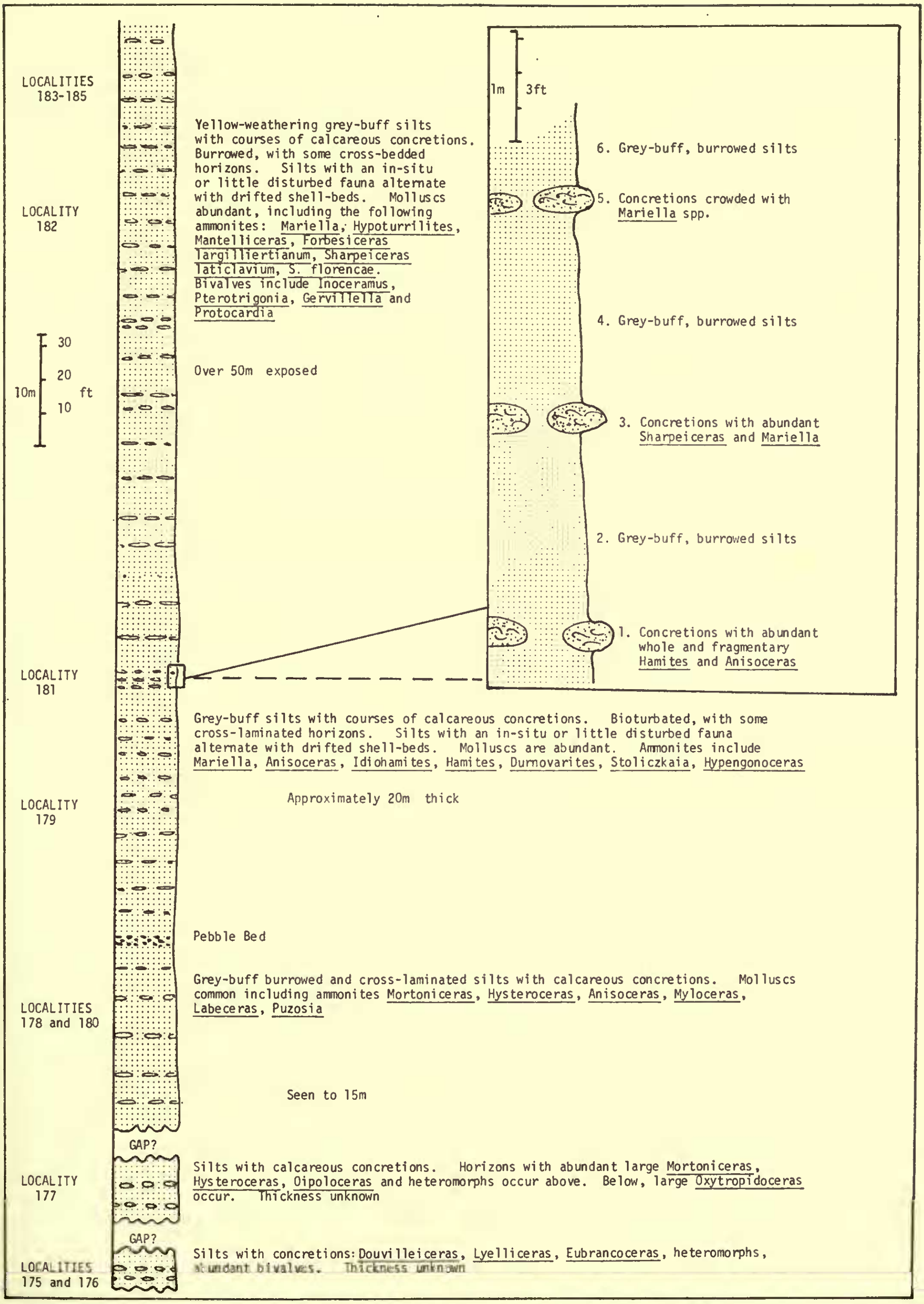


FIG. 12. The sequence around Ndumu, locs 175–185.

Loc. 178. Sisal field north of Msunduzi Pan, on Ndumu A location, 1400 m SW of Ndumu Store, 26° 56′ 14″ S, 32° 14′ 25″ E. Mzinene Formation.
AGE. Albian V–VI.

Loc. 179. Sisal fields north of the Msunduzi around the pumping station 2100 m SSW of Ndumu Store, 26° 56′ 28″ S, 32° 14′ 55″ E. Mzinene Formation.
AGE. Albian V–VI.

Loc. 180. Concretions in the bed of the Msunduzi by the bridge 1·8 km SSE of Ndumu Store, 26° 56′ 18″ S, 32° 15′ 25″ E. Mzinene Formation.
AGE. Albian V.

Loc. 181. Hill slopes east of the road, 1 km SE of Ndumu Store, 26° 55′ 51″ S, 32° 18′ 29″ E. Mzinene Formation.
AGE. Albian V, Cenomanian I–II.

Loc. 182. Ground surfaces over a radius of 300 m from Ndumu Store, 26° 55′ 38″ S, 32° 15′ 13″ E. Mzinene Formation.
AGE. Cenomanian II.

Loc. 183. Degraded quarry east of the road and 300 m SW of Ndumu police post, 26° 55′ 10″ S, 32° 15′ 45″ E. Mzinene Formation.
AGE. Cenomanian II.

Locs 184, 185. Hill slopes 600 m south and 500 m WSW of Ndumu police post, 26° 55′ 28″ S, 32° 15′ 57″ E and 26° 51′ 18″ S, 32° 16′ 10″ E. Mzinene Formation.
AGE. Cenomanian II.

Loc. 186. Makaane's Drift, 7·7 km south of Ndumu, 26° 59′ 28″ S, 32° 16′ 13″ E. Mzinene Formation.
AGE. Albian VI.

## VIII. DISCUSSION

The review and detailed description of sections given above outlines in broad terms the history of eastern South Africa during the Cretaceous.

In Zululand, actual exposures account for less than 1 per cent of the area currently shown on the 1 : 5 000 000 Carte Géologique d'Afrique (AGSA/UNESCO 1963). In spite of this, we have been able to estimate a thickness of at least a kilometre for the succession in the Mzinene–St Lucia region. The succession thickens markedly north-eastwards, presumably towards the centre of the basin. The Lower Cenomanian, of the order of 10 m in thickness along the Mzinene, has thus thickened to 100 m at Ndumu. In the same direction, progressively lower marine horizons appear, including previously unsuspected Upper Barremian sediments. Offshore, we would infer that even lower marine horizons are present, and that there is a continuous marine succession through the whole of the Cretaceous. The non-sequences we have noted are thus probably features of the marginal areas of the basin only, and borehole data suggest that marine sedimentation extended continuously into the Palaeocene.

A number of striking features of the succession are worthy of note at this point. The bulk of the marine sequence consists of glauconitic silt–sand grade clastics; pure clays are rare. Conglomerates are confirmed to the basal parts of the sequence or to minor units associated with breaks in the succession. Throughout the sequence, small-scale faunal/sedimentary cycles are conspicuous. These frequently take the form of alternations of drifted shell-beds, and silts with an *in situ* fauna, or sequences in which the sediment becomes finer in grade upwards. The base of each sequence is crowded with pelletal glauconite and rests on a sharp sedimentary discontinuity.

Small-scale sedimentary structures are singularly lacking throughout much of the sequence, especially the Mzinene and St Lucia Formations. This is due mainly to intense biogenic reworking of the sediment. Diagnostic trace-fossils are rare, but arthropod burrows (especially *Thalassinoides*) and *Chondrites* are abundant.

At several levels, high energy episodes disinterred early diagenetic concretions, which were subsequently bored by lithodomous bivalves, and encrusted by oysters, serpulids and other epizoans (Kennedy & Klinger 1972). These horizons are present in the Aptian and Lower Albian, where they indicate minor breaks in sedimentation. The 'hardground' at the Aptian/Albian boundary, however, is a palaeontologically detectable non-sequence and can be traced from Ndumu Spruit to the Nyalazi River. The bored surfaces of the concretions below the *Pterotrigonia shepstoni* conglomerate of Skoenberg represents part of Cenomanian, all Turonian and some of Coniacian time.

Faunally, the Zululand Group is impressive. Our collection of ammonites is fairly complete, but the few thousand bivalves and gastropods collected represent only a fraction of the diverse fauna awaiting systematic and palaeoecological analysis. Macroinvertebrate groups other than the Bivalvia, Gastropoda and Cephalopoda form only a minority of the fauna. Belemnites occur in numbers only in the Aptian. Echinoids are scarce save for a few levels in the Albian and Cenomanian. Brachiopods are common at only two levels in the Albian, although they range from Aptian to Maastrichtian.

Ahermatypic corals are common only in the Cenomanian ; only one hermatype is known, and is of Aptian age. Arthropods range throughout but (except cirripede bores and ubiquitous burrows) are rare. Serpulids are frequent throughout ; bryozoans less so. We have seen no macroscopic sponge remains.

Vertebrates are not common. Other than fish fragments (largely teeth) we have noted occurrences of large reptilian remains only in the Lower Albian and the Santonian–Lower Campanian. In contrast, plant remains are incredibly abundant from the Barremian through to the Lower Campanian. Logs, up to several metres long and 60 cm in diameter, are common at many levels, and in the Barremian–Aptian there is a series of log beds. Lignite chips form an appreciable portion of the sediment at many levels up into the Campanian.

Many of the above comments can also be applied to the Umzamba Formation below and south of Durban. There, the bulk of the clastic material is sand–silt sized, although a coarser glauconite fraction is more conspicuous than to the north. Small-scale sedimentary rhythms are present and the sequence is bioturbated. The fauna of the Umzamba Formation is far better documented than that of the Zululand Series. It is predominantly molluscan ; we know of one coral, no brachiopods, belemnites, nor macroscopic sponge remains. Echinoids are scarce, save at one horizon ; arthropods (cirripede bores and burrows excepted) are absent. Serpulids and bryozoans range throughout. Wood, with logs several metres long, is abundant. Lignite chips form an appreciable part of the sediment. Vertebrates are relatively common at the base of the sequence; Broom (1907) records a large mosasaur, a plesiosaur and abundant chelonian debris. Woodward (1907) records elasmobranch and teleost teeth.

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## X. REFERENCES

ANDERSON, W. 1902. Report on a reconnaissance Geological Survey of the eastern half of Zululand with a geological sketch map of the country traversed. *Rep. geol. Surv. Natal Zululand*, Pietermaritzburg, **1** : 37–66, pl. 19.

—— 1904. Further notes on the reconnaissance Geological Survey of Zululand. *Ibid.* **2** : 39–67.

—— 1906. On the geology of the Bluff Bore, Durban, Natal. *Trans. geol. Soc. S. Afr.*, Johannesburg, **9** : 111–113.

—— 1907. The Upper Cretaceous rocks of Natal and Zululand. *Rep. geol. Surv. Natal Zululand*, Pietermaritzburg, **3** : 47–64.

BASSE, E. 1947. Paléontologie de Madagascar 26. Les peuplements Malgaches de *Barroisiceras*. Révision du genre *Barroisiceras* de Gross. *Annls Paléont.*, Paris, **33** : 100–190, 9 pls.

BESAIRE, H. 1930. Les rapports du Crétacé Malgache avec le Crétacé de l'Afrique australe. *Bull. Soc. géol. Fr.*, Paris, (4) **30** : 613–643, pls 64–67.

—— & LAMBERT, J. 1930. Note sur quelques échinides de Madagascar et du Zululand. *Bull. Soc. géol. Fr.*, Paris, **30** : 107–117, 2 pls.

BOSHOFF, J. C. 1945. *Stratigraphy of the Cretaceous System in the Nduma area of Northern Zululand* (unpublished M.Sc. Thesis, University of Pretoria).

BOUCHÉ, P. M. 1965. Nannofossiles calcaires. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 131–138.

BROOM, R. 1907. On some reptilian remains from the Cretaceous Beds at the mouth of the Umpenyati River. *Rep. geol. Surv. Natal Zululand*, Pietermaritzburg, **3** : 95.

—— 1912. On a species of *Tylosaurus* from the Upper Cretaceous Beds of Pondoland. *Ann. S. Afr. Mus.*, Cape Town, **7** : 332–333, pl. 22.

BUSNARDO, R. 1965a. Lithologie et macrofaune. *In* Le Stratotype du Barrémien. Colloque sur le Crétacé Inférieur. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 101–116.
—— 1965b. Rapport sur l'étage Barremien. *Ibid.* : 161–169.
CASEY, R. 1961. The stratigraphical palaeontology of the Lower Greensand. *Palaeontology*, London, **3** : 487–621, pls 77–84.
CHAPMAN, F. 1904. Foraminifera and Ostracoda from the Cretaceous of East Pondoland, South Africa. *Ann. S. Afr. Mus.*, Cape Town, **4** : 221–237, pl. 29.
—— 1923. On some Foraminifera and Ostracoda from the Cretaceous of Umzamba River, Pondoland. *Trans. geol. Soc. S. Afr.*, Johannesburg, **26** : 1–6, pl. 1.
COLLIGNON, M. 1959. Corrélations sommaires entre les dépôts du Crétacé Supérieur de Madagascar et ceux de l'Europe occidentale, en particulier de la France. *In* Colloque sur le Crétacé Supérieur Français. *C. r. Congr. Socs sav. Paris Sect. Sci.* (Dijon), **1959** : 41–52.
—— 1965a. L'Albien à Madagascar. Ses subdivisions comparées à celles de l'Europe occidentale : essai de chronostratigraphie aussi générale que possible. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 303–310.
—— 1965b. *Atlas des Fossiles Caractéristiques de Madagascar* (*Ammonites*) **13** (Coniacien). 88 pp., pls 415–454. Serv. Géol., Tananarive.
COQUAND, D. H. 1857. Sur le position des *Ostrea columba* et *biauriculata* dans le groupe de la Craie Inférieur. *Bull. Soc. géol. Fr.*, Paris, **14** : 745–770.
—— 1862. Sur la convenance d'établir dans le groupe inférieur de la formation crétacée un nouvel étage entre le néocomien proprement dit (couches à *Toxaster complanatus* et à *Ostrea couloni*) et le néocomien supérieur (étage urgonien d'Alc. d'Orbigny). *Bull. Soc. géol. Fr.*, Paris, (2) **19** : 531–541.
CRICK, G. C. 1907a. The Cephalopoda from the deposit at the North End of False Bay, Zululand. *Rep. geol. Surv. Natal Zululand*, Pietermaritzburg, **3** : 163–234, pls 10–15.
—— 1907b. The Cephalopoda from the tributaries of the Manuan Creek, Zululand. *Ibid.* : 235–249.
—— 1907c. Note on a Cretaceous ammonite from the mouth of the Umpenyati River, Natal. *Ibid.* : 250.
—— 1907d. The Cretaceous rocks of Natal and Zululand and their Cephalopod fauna. *Geol. Mag.*, London, **4** : 339–347.
DALBIEZ, M. F. 1959. Rapport V : Corrélations et résolutions. *In* Colloque sur le Crétacé Supérieur Français. *C. r. Congr. Socs sav. Paris Sect. Sci.* (Dijon), **1959** : 857–867.
DAVEY, R. J. 1969. Some dinoflagellate cysts from the Upper Cretaceous of northern Natal, South Africa. *Palaeont. afr.*, Johannesburg, **12** : 1–23, 4 pls.
DESTOMBES, P. & DESTOMBES, J. P. 1965. Distribution zonale des ammonites dans l'Albien du Bassin de Paris. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 255–270.
DIETRICH, W. O. 1938. Zur Stratigraphie der Kreide im nordlichen Zululand. *Zentbl. Miner. Geol. Paläont.*, Stüttgart, (B) **1938** : 228–240.
DINGLE, R. V. 1969. Upper Senonian ostracods from the coast of Pondoland, South Africa. *Trans. R. Soc. S. Afr.*, Cape Town, **38** : 347–385, 21 figs.
DRUZHCHITZ, V. V. 1963a. Stratigraphic position of the *Colchidites* Beds, *Colchidites securiformis* Zone. *Dokl. Akad. Nauk. SSSR*, Leningrad, **147** : 115–117 (in Russian).
—— 1963b. The Hauterivian–Barremian boundary. *Ibid.* : 900-903 (in Russian).
DUMONT, A. 1850. Rapport sur la carte géologique du royaume. *Bull. Acad. r. Belg.*, Bruxelles, **16** : 351–373.
DU TOIT, A. L. 1920. *The Geology of Pondoland and portions of Alfred and Lower Umzimkulu Counties, Natal. An Explanation of Cape Sheet* **28** (*Pondoland*). 45 pp. Geological Survey, Pretoria.
—— 1954. *Geology of South Africa.* 3rd edition. 611 pp., 73 figs, 41 pls. Edinburgh.
—— & VAN HOEPEN, E. C. N. 1929. *Guide Book. Excursion C18, Durban–Zululand.* 20 pp. XV Int. geol. Congr. South Africa, Pretoria.
ERISTAVI, M. S. 1955. Fauna of the Lower Cretaceous of Georgia. *Monogr. Inst. Geol. Akad. Nauk Gruz. SSR*, Tiflis, **6** : 1–224, 8 pls (in Russian).

ETHERIDGE, R. 1904. Cretaceous fossils of Natal. 1. The Umkwelane Hill Deposit. *Rep. geol. Surv. Natal Zululand*, Pietermaritzburg, **2** : 71–93, pls 1–3.
—— 1907. Cretaceous fossils of Natal. 2. The Umzinene River Deposit, Zululand. *Ibid.* **3** : 67–90, pls 1–6.
FABRE-TAXY, S., MOULLADE, M. & THOMEL, G. 1965. Le Bédoulien dans sa région type, la Bédoule-Cassis (B.-du-R.). *In* Les Stratotypes de l'Aptien. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 173–199.
FAURE, D. 1965. Le Barrémien du sud du couloir Rhodanien. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 139–146.
FLANDRIN, J. 1965. Rapport sur l'étage Aptien. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 227–234.
FRANKEL, J. J. 1960a. The geology along the Umfolozi River, south of Mtubatuba, Zululand. *Trans. geol. Soc. S. Afr.*, Johannesburg, **63** : 231–252, pls 33–36.
—— 1960b. Late Mesozoic and Cenozoic events in Natal, South Africa. *Trans. N. Y. Acad. Sci.*, **22** : 565–577.
FURON, R. 1950. *Géologie de l'Afrique.* 350 pp., 34 figs. Paris.
—— 1963. *Geology of Africa.* 377 pp. Edinburgh.
GARDEN, R. J. 1855. Notice of some Cretaceous rocks near Natal, South Africa. *Q. Jl geol. Soc. Lond.*, **11** : 453–454.
GEVERS, T. W. & LITTLE, J. DE V. 1946. Upper Cretaceous beds between Intongazi and Umkandandhlobu Rivers, Alfred Country, Natal. *Trans. geol. Soc. S. Afr.*, Johannesburg, **48** : 27–29.
GÖTTSCHE, C. 1887. Ueber die obere Kreide von Umtafuna (S. Natal). *Z. dt. geol. Ges.*, Berlin, **39** : 622–624.
GRIESBACH, C. L. 1871. On the geology of Natal in South Africa. *Q. Jl Geol. Soc. Lond.*, **27** : 53–72, pls 2, 3.
GROSSOUVRE, A. DE 1894. Recherches sur la Craie Supérieure. **2**, Paléontologie. Les ammonites de la Craie Supérieure. *Mém. Serv. Carte géol. dét. Fr.*, Paris, 264 pp., atlas of 39 pls.
—— 1900. Types du Turonien de Touraine et du Cénomanien du Mans. *Excursion guide, VIII Int. géol. Congr.*, Paris, **5** : 1–10.
—— 1901. Recherches sur la Craie Supérieure. **1**, Stratigraphie générale. *Mém. serv. Carte géol. dét. Fr.*, Paris, 1013 pp.
GUILLAME, S. & SIGAL, J. 1965. Les Foraminifères. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 117–129.
HAAS, O. 1942. The Vernay collection of Cretaceous (Albian) ammonites from Angola. *Bull. Am. Mus. nat. Hist.*, New York, **81** : 1–224, pls 1–47.
HALLOY, O. DE 1808. Essai sur la géologie du Nord de la France. *J. Mines, Paris*, **52** : 271–318.
HANCOCK, J. M. 1959. Les ammonites du Cénomanien de la Sarthe. *In* Colloque sur le Crétacé Supérieur Français. *C. r. Congr. Socs sav. Paris Sect. Sci.* (Dijon), **1959** : 249–259.
HAUGHTON, S. H. 1936a. Account of the geology of the Cretaceous Beds of Northern Zululand. *Ann. S. Afr. Mus.*, Cape Town, **31** : 283–294.
—— 1936b. Preliminary analysis of the ammonite fauna of Northern Zululand. *Ibid.*: 295–297.
—— 1959. *Geological Bibliography of Africa south of the Sahara. Bibliography of the Jurassic and Cretaceous Systems.* Commission de co-opération technique en Afrique au sud du Sahara. iii + 83 pp. London.
—— 1963. *The Stratigraphic History of Africa south of the Sahara.* xii + 365 pp. Edinburgh and London.
—— 1969. *Geological History of Southern Africa.* Geol. Soc. S. Afr. 535 pp. Cape Town.
HEINZ, R. 1930. Ueber Kreide-Inoceramen der südafrikanischen Union. *C. r. XV Int. geol. Congr.*, Cape Town, **2** : 681–687.

JUIGNET, P., KENNEDY, W. J. & WRIGHT, C. W. 1973. Remarques sur la limite Cenomanien–Turonien dans la région du Mans (Sarthe). *Annls Paléont., Paris,* **59** (Invert. 2) : 207–250, pls 1–3.

KENNEDY, W. J. 1969. The correlation of the Lower Chalk of south-east England. *Proc. Geol. Ass.*, London, **80** : 459–560, pls 15–22.

—— 1970. The correlation of the Uppermost Albian and Cenomanian of south-west England. *Ibid.* **81** : 613–675.

—— 1971. Cenomanian ammonites from southern England. *Spec. Pap. Palaeont.*, London, **8** : 133 pp., 64 pls.

—— & HANCOCK, J. M. 1971. *Mantelliceras saxbii* (Sharpe) and the horizon of the Martimpreyi Zone in the Cenomanian of England. *Palaeontology*, London, **14** : 437–454, pls 79–82.

—— & JUIGNET, P. 1973. Observations on the lithostratigraphy and ammonite succession across the Cenomanian–Turonian boundary in the environs of Le Mans (Sarthe, N.W. France). *Newsl. Stratigr.*, Leiden, **2** (4) : 189–202.

—— & KLINGER, H. C. 1971. A major intra-Cretaceous unconformity in eastern South Africa. *Jl geol. Soc.*, London, **127** : 183–186.

—— —— 1972. Hiatus concretions and hardground horizons in the Cretaceous of Zululand, South Africa. *Palaeontology*, London, **15** : 539–549, pls 106–108.

KILIAN, W. 1902a. Sur la présence de l'étage Aptien dans le Sud-Est de l'Afrique. *C. r. hebd. Séanc. Acad. Sci., Paris,* **75** : 68.

—— 1902b. Sur quelques gisements de l'étage Aptien. *Bull. Soc. géol. Fr.*, Paris, **2** : 358.

—— 1902c. Ueber Aptien in Südafrika. *Zentbl. Miner. Geol. Paläont.*, Stuttgart, **1902** : 465–468.

KING, L. A. 1962. The post Karroo stratigraphy of Durban. *Trans. geol. Soc. S. Afr.*, Johannesburg, **65** (2) : 85–93.

KING, L. C. & MAUD, R. M. 1964. The geology of Durban. *Bull. geol. Surv. Rep. S. Afr.* **42** : 1–54.

KRENKEL, E. 1910a. Die untere Kreide von Deutsch Ost-Afrika. *Beitr. Paläont. Geol. Ost.-Ung.*, Vienna & Leipzig, **23** : 201–250, pls 20–23.

—— 1910b. Die Aptfossilien der Delagoa Bai. *Neues Jb. Miner. Geol. Paläont. Jahrg.*, Stüttgart, **1910** (1) : 142–168, fig. 17.

—— 1911a. Zur unteren Kreide von Deutsch Ost-Afrika. *Zentbl. Miner. Geol. Paläont.*, Stuttgart, **1911** : 285.

—— 1911b. Die Entwickelung der Kreideformation auf dem afrikanischen Kontinente. *Geol. Rdsch.*, Leipzig, **2** : 330–366.

KRIGE, L. J. 1932. The geology of Durban. *Trans. geol. Soc. S. Afr.*, Johannesburg, **35** : 37–67.

LANG, W. D. 1906. Polyzoa. *In* WOODS, H. The Cretaceous fauna of Pondoland. *Ann. S. Afr. Mus.*, Cape Town, **4** : 275–350, pls 33–45.

LARCHER, C., RAT, P. & MALPRIS, M. 1965. Documents paléontologiques et stratigraphiques sur l'Albien de l'Aube. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 237–253.

LITTLE, J. DE V. 1957. A new species of *Trigonia* from Upper Cretaceous Beds near the Itongazi River, Natal. *Palaeont. afr.*, Johannesburg, **4** : 117–122.

MANDEL, E. 1960. Monimiacean-Hölzer aus der oberkretazischen Umzambaschichten von Ost-Pondoland, S. Afrika. *Senckenberg. leth.*, Frankfurt a.M., **41** : 331–391, 10 pls.

MARIE, P. 1965. Sur une échelle stratigraphique de l'Albien du Bassin Parisien basée sur les foraminifères. *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 271–288.

MIDDLEMISS, F. A. & MOULLADE, M. 1970. Summer Field Meeting in the south of France between Lyon and Avignon. *Proc. Geol. Ass.*, London, **81** : 303–362.

MONTANARO, E. & LANG, Z. 1937. Coelenterati, echinodermi, e brachiopodi del cretaceo medio-superiore dello Zululand. *Palaeontogr. ital.*, Pisa, **37** : 193–201, 1 pl.

MOULLADE, M. 1965a. Révision des stratotypes de l'Aptien : Gargos (Vaucluse). *Mém. Bur. Rech. géol. minièr.*, Paris, **34** : 201–214.

—— 1965b. Révision des stratotypes de l'Aptien Clansayes (Drôme). *Ibid.* : 303–310.

MUIR-WOOD, H. M. 1953. Description of a new species of "*Terebratula*" from the Cretaceous of Zululand. *Trans. geol. Soc. S. Afr.*, Johannesburg, **55** : 183–187, pl. 19.

MULLER-STOLL, W. R. & MANDEL, E. 1972. Fossil woods of Monimiacea and Euphorbiacea from the Upper Cretaceous Umzamba Beds of East Pondoland, C.P. *Trans. geol. Soc. S. Afr.*, Johannesburg, **65** : 93–104.

NEWTON, R. B. 1909. Cretaceous Gasteropoda and Pelecypoda from Zululand. *Trans. R. Soc. S. Afr.*, Cape Town, **1** : 1–106, pls 1–9.

ORBIGNY, A. D' 1840–42. *Paléontologie française. Terrains Crétacés I. Céphalopodes.* 662 pp., 148 pls. Paris.

—— 1848–51. *Paléontologie française. Terrains Crétacés IV. Brachiopodes.* 390 pp., 109 pls. Paris.

—— 1850. *Prodrome de Paléontologie stratigraphique universelle des animaux mollusques et rayonnés*, **2**. 427 pp. Paris.

—— 1852. *Cours élémentaire de Paléontologie et de Géologie stratigraphique*, **2** (2) : 383–847. Paris.

OWEN, H. G. 1971. Middle Albian stratigraphy in the Anglo-Paris Basin. *Bull. Br. Mus. nat. Hist.* (Geol.), London, Suppl. **8** : 164 pp., 3 pls.

PIENAAR, R. N. 1969. Upper Cretaceous calcareous nannoplankton from Zululand, South Africa. *Palaeont. afr.*, Johannesburg, **12** : 75–128, 11 pls.

PLOWS, W. J. 1921. The Cretaceous rocks of Pondoland. *Ann. Durban Mus.*, **3** : 58–66, pl. 8.

RENNGARTEN, V. P. 1926. La faune des dépôts crétacés de la région d'Assakambiléevka, Caucase du Nord. *Trudÿ geol. Kom.*, Leningrad, N.S. **147** : 132 pp., 9 pls (in Russian, French résumé).

RENNIE, J. V. L. 1929. Cretaceous fossils from Angola (Lamellibranchia and Gastropoda). *Ann. S. Afr. Mus.*, Cape Town, **28** : 1–54, pls 1–5.

—— 1930. New Lamellibranchia and Gastropoda from the Upper Cretaceous of Pondoland (with an appendix on some species from the Cretaceous of Zululand). *Ibid.* : 159–260, pls 16–31.

—— 1935. On a new species of *Lysis* (Gastropoda) from the Cretaceous of Pondoland. *Rec. Albany Mus.*, Grahamstown, **4** : 244–247, pl. 24.

—— 1936. Lower Cretaceous Lamellibranchia from Northern Zululand. *Ann. S. Afr. Mus.*, Cape Town, **31** : 277–391, pls 37–55.

ROGERS, A. W. & SCHWARZ, E. H. L. 1901. Report on parts of the Uitenhage and Port Elizabeth Divisions. *Rep. geol. Commn Cape Good Hope*, Cape Town, **1900** (1) : 3–18.

—— —— 1902. General survey of the rocks in the southern parts of the Transkei and Pondoland including a description of the Cretaceous rocks of eastern Pondoland. *Ibid.* **1901** (25) : 25–46.

RONIEWICZ, P. 1970. Borings and burrows in the Eocene littoral deposits of the Tatra Mountains, Poland. *Geol. J.*, Liverpool, Spec. Issue **3** : 439–446, 2 pls.

ROUCHADZÉ, J. 1932. Les ammonites aptiennes de la Géorgie Occidentale. *Bull. Inst. géol. Géorgie*, Tiflis, **1** : 165–273, pls 1–23.

SCHELPE, E. A. C. L. E. 1955. *Osmundites natalensis*—a new fossil fern from the Cretaceous of Zululand. *Ann. Mag. nat. Hist.*, London, (12) **8** : 652–656, pl. 17.

SELLWOOD, B. W. 1970. The relation of trace fossils to small scale sedimentary cycles in the British Lias. *Geol. J.*, Liverpool, Spec. Issue **3** : 489–504, 1 pl.

SÉRONIE-VIVIEN, M. 1959. Les localités types du Sénonien dans les environs de Cognac et Barbezieux (Charente). *In* Colloque sur le Crétacé Supérieur Français. *C. r. Congr. Socs sav. Paris Sect. Sci.* (Dijon), **1959** : 579–589.

SMITTER, Y. H. 1956. Foraminifera from the Upper Cretaceous beds occurring near the Itongazi River, Natal. *Palaeont. afr.*, Johannesburg, **3** : 103–107.

—— 1957. Upper Cretaceous Foraminifera from Sandy Point, St Lucia Bay, Zululand. *S. Afr. J. Sci.*, Cape Town, **53** : 195–201.

SOCIN, C. 1939. Gasteropodi e Lamellibranchi del Cretaceo medio-superiore dello Zululand. *Palaeontogr. ital.*, Pisa, **40** : 21–38, pls 5–6.

SORNAY, J. (Ed.) 1957. France, Belgique, Pays-Bas, Luxembourg. Crétacé. *In Lexique Stratigraphique International I (Europe)*, **4 a VI**, 403 pp. CNRS, Paris.

SPATH, L. F. 1921a. On Cretaceous Cephalopoda from Zululand. *Ann. S. Afr. Mus.*, Cape Town, **12** : 217–321, pls 19–26.

—— 1921b. On Upper Cretaceous Ammonoidea from Pondoland. *Ann. Durban Mus.*, **3** : 39–57, pls 6, 7.

—— 1922. On the Senonian ammonite fauna of Pondoland. *Trans. R. Soc. S. Afr.*, Cape Town, **10** : 113–147, pls 5–9.

—— 1923–43. A monograph of the Ammonoidea of the Gault. *Palaeontogr. Soc. (Monogr.)*, London, 787 pp., 72 pls.

—— 1925. On Upper Albian Ammonoidea from Portuguese East Africa. *Ann. Transv. Mus.*, Pretoria, **11** : 179–216, 10 pls.

—— 1953. The Upper Cretaceous Cephalopod fauna of Grahamland. *Scient. Rep. Falkld Isl. Depend. Surv.*, London, **3** : 60 pp., 13 pls.

TATE, R. 1867. On some secondary fossils from South Africa. *Q. Jl geol. Soc. Lond.*, **23** : 139–174, pls 3–9.

VAN HOEPEN, E. C. N. 1920. Description of some Cretaceous ammonites from Pondoland. *Ann. Transv. Mus.*, Pretoria, **7** : 142–147, pls 24–26.

—— 1921. Cretaceous Cephalopoda from Pondoland. *Ibid.* **8** : 1–48, pls 1–11.

—— 1926. Oor die Krytafsettinge van Soeloeland. *S. Afr. J. Sci.*, Cape Town, **23** : 216–222.

—— 1929. Die Krytfauna van Soeloeland. I. Trigoniidae. *Paleont. Navors. nas. Mus. Bloemfontein*, **1** : 1–38, pls 1–7.

—— 1931. Die Krytfauna van Soeloeland. 2. Voorlopige Beskrywing van enige Soeloelandse Ammoniete. 1. *Lophoceras, Rhytidoceras, Drepanoceras* en *Deiradoceras*. *Ibid.* : 39–54, 14 figs.

—— 1941. Die gekielde Ammoniete van die Suid-Afrikaanse Gault. I. Diploceratidae, Cechenoceratidae en Drepanoceratidae. *Ibid.* : 55–90, figs 1–55, pls 8–19.

—— 1942. Die gekielde Ammoniete van die Suid-Afrikaanse Gault. II. Drepanoceratidae, Pervinquieridae, Arestoceratidae, Cainoceratidae. *Ibid.* : 91–157, figs. 56–173.

—— 1944. Die gekielde Ammoniete van die Suid-Afrikaanse Gault. III. Pervinquieridae en Brancoceratidae. *Ibid.* : 159–198, pls 20–26.

—— 1946. Die gekielde Ammoniete van die Suid-Afrikaanse Gault. IV. Cechenoceratidae, Dipoloceratidae, Drepanoceratidae, Arestoceratidae. [and] V. Monophyletism or polyphyletism in connection with the ammonites of the South African Gault. *Ibid.* : 199–271, figs. 174–268.

—— 1951a. Die gekielde Ammoniete van die Suid-Afrikaanse Gault. VI. The so-called old mouth-edges of the ammonite shell. *Ibid.* : 273–284, figs 269–287.

—— 1951b. Die gekielde Ammoniete van die Suid-Afrikaanse Gault. VII. Pervinquieridae, Arestoceratidae, Cainoceratidae. *Ibid.* : 285–344, figs 288–442.

—— 1951c. A remarkable desmoceratid from the South African Albian. *Ibid.* : 345–349, 3 figs.

—— 1955a. New and little-known ammonites from the Albian of Zululand. *S. Afr. J. Sci.*, Cape Town, **51** : 355–377, figs 1–31.

—— 1955b. A new family of keeled ammonites from the Albian of Zululand. *Ibid.* : 377–382, figs 32–36.

—— 1963. An Albian astacurid from Zululand. *Ann. geol. Surv. Pretoria*, **1** : 253–255.

—— 1966a. New and little known Zululand and Pondoland ammonites. *Ann. geol. Surv. Pretoria*, **4** : 158–172, 12 pls.

—— 1966b. New ammonites from Zululand. *Ibid.* : 183–186, 7 pls.

—— 1966c. The Peroniceratidae and allied forms of Zululand. *Mem. geol. Surv. Rep. S. Afr.*, Pretoria, **55** : 70 pp., 27 pls.

VENZO, S. 1936. Cefalopodi del Cretacea medio-superiore dello Zululand. *Palaeontogr. ital.*, Pisa, **36** : 59–133, pls 5–12.

WIEDMANN, J. 1959. La Crétacé supérieur de l'Espagne et du Portugal et ses céphalopodes. *In* Colloque sur le Crétacé Supérieur Français. *C. r. Congr. Socs sav. Paris Sect. Sci.* (Dijon), **1959** : 709–764, 7 pls.

—— 1964. Le Crétacé supérieur de l'Éspagne et du Portugal et ses Céphalopodes. *Estudios geol. Inst. geol. Lucas Mallada*, Madrid, **1964** : 107–148, 39 figs.

WOODS, H. 1906. The Cretaceous fauna of Pondoland. *Ann. S. Afr. Mus.*, Cape Town, **4** : 275–350, pls 33–44.

WOODWARD, A. S. 1907. Notes on some Cretaceous fish teeth from the mouth of the Umpenyati River, Natal. *Rep. geol. Surv. Natal Zululand*, Pietermaritzburg, **3** : 99–101, pl. 10 (pars).

WRIGHT, C. W. 1957. Mollusca 4. Cephalopoda, Ammonoidea. *In* Moore, R. C. (Ed.), *Treatise on Invertebrate Paleontology*, **L.** xxii + 400 pp. Lawrence, Kansas.

## XI. INDEX

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## PLATE

Fig. 1. *Megatrigonia* shell bed, Makatini Formation (Aptian), loc. 39, Mzinene River, Zululand. Hammer-head is 15 cm long. (p. 285).

Fig. 2. Inoceramid fragments in Maastrichtian silts, St Lucia Formation, SE shores of Lake St Lucia, Zululand. Hammer-head is 15 cm long. (p. 298).